Tournament-Style Evaluation with tournament-style evaluation to reduce the evaluation load of IEC users. Most previous studies did not clearly demonstrate the effectiveness of the tournament-style evaluation. Therefore, we implemented a tournament-style evaluation for a specific application and inspected the effectiveness of the IEC with tournament-style evaluation using an experiment with real users. We used three evaluation objects: music, animation, and image. We evaluated the performance of the following three methods. The first was a normal IGA (NIGA), which is a conventional 10-stage evaluation. The second was a tournament-style method with two levels of evaluation (T2), which evaluates only the superiority or inferiority of two candidates at a time. The third was a tournament-style method with four levels of evaluation (T4), which progressively evaluates the superiority or inferiority of two candidates. We inspected the effectiveness of these methods by simulation using an evaluation agent that imitated human preferences (or Kansei). The simulation results showed that the evolution performances of the NIGA and T2 are higher than those of the T4. Also, we inspected the effectiveness of these methods by an evaluation experiment with 42 subjects. The experiment results showed that the satisfaction level for generated candidates were approximately equal among the NIGA, T2, and T4. Moreover, with the T2, it was easiest for test subjects to evaluate solution candidates than with the NIGA in all evaluation objects. And with the T4, it was easier for test subjects to evaluate solution candidates when the evaluation objects were music and image than with the NIGA.

Computational Intelligence in Finance, Economics and Management Sciences (IEEE-CEC), Large-scale problems. cases with the goal of improving medium term bankruptcy prediction accuracy in large uncontrolled datasets of financial records. We propose a Genetic Programming and Neural Network based objective feature selection methodology to identify key inputs, and then use those inputs to combine multi-level Self-Organising Maps with Spectral Clustering to build clusters. Performing objective feature selection within each of those clusters, this research was able to increase out-of-sample classification accuracy from 71.3percent and 69.8percent on the Genetic Programming and Neural Network models respectively to 80.0percent and 77.3percent.

Constraint-Handling Mechanism strategy to determine the control parameters is proposed to solve constrained real-parameter optimisation, combining with the dynamic constraint-handling mechanism. parameter optimisation. It is implemented by restating the single- objective constrained optimisation as a set of single-objective unconstrained problems and dynamically assigning to the individual adaptively as its fitness. The approach is tested on a suit of test problems proposed for CEC2010 competition and special session on single objective constrained real- parameter optimisation. The results obtained are discussed and some conclusions are made.

for High-Dimensional Search Spaces and swarm intelligence algorithms have been developed to solve this type of problems. Particle Swarm Optimisation (PSO) presents a fast convergence in continuous problems, but it can not maintain diversity along the search process. On the other hand, Artificial Bee Colony (ABC) presents the capability to generate diversity when the guide bees are in the exploration mode. We propose in this paper to introduce a mechanism based on the ABC to generate diversity in an adaptive PSO approach and analyse its performance in high dimensional search spaces. The swarm switches its behaviour depending on the dispersion of the swarm. We evaluated our proposal in a well known set of 20 benchmark functions recently proposed in 2010 and our proposal achieved better performance than PSO, APSO and ABC in most of the cases.

many improvements of PSO which have not change the basic paradigm of PSO involving pattern of movement of particles, update mode of particles and algorithm framework. Instead of another improvement of PSO, a novel paradigm of PSO with more natural and simpler forms, called naive PSO, is proposed, based on a slightly different social metaphor from that of the original PSO: each particle learns from better one in the swarm and takes warning from worse one in the swarm. In the naive PSO, pattern of movement and mode of update of particles differing from that in the original PSO is introduced. After an algorithm framework is presented, stochastic parameter analysis is also carried out. Preliminary computational experiences show that the naive PSO has a competitive performance over the standard PSO. And then two modifications of the naive PSO are devised. Combining the two modifications, the improved naive PSO shows significantly superior performance over the standard PSO and competitive performance over differential evolution.

Problem. The single-objective formulation of the problem has been widely studied in the related literature, trying to optimise the total volume of the packed pieces into the container. However, a rather common aspect in the scope of this problem is the weight limit of the containers, since they normally can not exceed a certain weight for their transportation, and they should make the most without

exceeding that limit. For this reason, we have focused on a multi-objective formulation of the problem which seeks to maximise the volume at the same time that the weight, without exceeding the weight limit. To solve this multi-objective problem we have applied multi-objective optimisation evolutionary algorithms given their great effectiveness with other types of real-world multi-objective problems. One of the goals of this work is to improve the results of the only known work in the literature that addresses the same problem with multiple objectives. Once we have achieved it, we have parallelised the problem applying different island-based models to enhance the effectiveness and efficiency of our approach.

Gesture Recognition in Human-Robot Interaction robust hand segmentation and fingertip extraction for finger gesture recognition in Human-robot interaction (HRI). Firstly, we propose an improved cascade filtering based hand region candidate estimation by the combination of YCbCr skin colour probability image based segmentation with genetic algorithm and post-Processing with morphological operation and blob analysis in blurred, low-resolution images. Using the segmented hand candidate regions, we estimate the hand region cent and fingertip position from distance transform and geometrical feature of hand. From the hand orientation and hand/palm cent, we find the optimal each fingertip position and its orientation. Experimental results show that the proposed algorithm not only rapidly detects the hand regions under various illumination conditions, but also it efficiently extracts the finger information with size and rotation invariance.

optimization device (EHD), by means of a recently developed evolutionary optimisation method. This procedure is developed in order to increase the transfer efficiency and the robustness of the coupling, with the aim of minimising the average power loss, and to increase the lifetime of a wireless sensor network by scavenging RF energy available in the environment.

of Differential Evolution(DE) is proposed based on the elaborate analysis of intrinsic structure. The projection information of fitness function in differential direction is used to get the scale factor, while the difference between the local distance and global search range is applied to determine the crossover rate. This approach is tested by the benchmark including unconstrained uni-Modal, multi-Modal and bound-constrained functions, and the results indicate it has good performance in balance between explorative and exploitative tendencies than standard DE and easy to be implemented widely with many variants of DE algorithm.

algorithms Expensive Problems, Meta-modelling and surrogate models model to assist a genetic algorithm (GA) in solving optimisation problems with a limited computational budget. We compared the impact to the evolutionary search introducing three surrogate models: (i) averaged inheritance, (ii) weighted inheritance and (iii) parental inheritance. Numerical experiments are performed in order to assess the applicability and the performance of the proposed approach. The results show that when using a fixed reduced budget of expensive simulations, the surrogate-assisted genetic algorithm allows for improving the final solutions when compared to the standard GA. We find that the averaged and parental inheritance are most effective when compared to weighted inheritance, and they are strongly recommended for use in further investigations of optimisation using GA-based search.

networks applications, including data clustering and social network analysis. We present path-sharing, a new measure of betweenness, for use in identifying densely connected clusters in networks. We show that path-sharing performs well at identifying communities in artificial benchmark networks, giving performance comparable to that of state-of-the-art community identification techniques. We also demonstrate a practical use of path-sharing when used in community identification, by applying it to an image segmentation problem.

Optimization Task data mining clonal selection principle exhibited in natural and artificial immune systems. The method, called Clonal Selection Classifier with Data Reduction (CSCDR), uses a fitness function based on the number of correct and incorrect pattern classifications made by each antibody. The algorithm tries to maximise this value through clonal selection processes such as mutation, affinity maturation and selection of the best individuals, transforming the training phase in an optimisation problem. This leads to antibodies with more representativeness and thus decreases the amount of prototypes generated at the end of the algorithm. Experimental results on benchmark datasets of the UCI machine learning repository demonstrated the effectiveness of the CSCDR algorithm as a classification technique, combined with a considerable data reduction when compared to the results obtained by the well known Artificial Immune Recognition System (AIRS) and the original Clonal Selection Classifier Algorithm (CSCA).

Multiobjective Evolutionary Algorithm based on NSGA-II Bioinformatics to carry out other outstanding tasks like structural predictions, biological function analysis or next-generation sequencing. However,

MSA algorithms do not achieve consistent results in all cases, as alignments become difficult when sequences have low similarity. In other words, each algorithm is focused in specific features of sequences and their results depend on them. For this reason, each approach could align better those sections of sequences that include such features, obtaining partially optimal solutions. In this work, a multiobjective evolutionary algorithm based on NSGA-II will be implemented in order to assemble previously aligned sequences, trying to avoid suboptimal alignments.

military unit combination strategies for winning an attacking rush in a real-time strategy (RTS) game. A modified version of Evolutionary Programming (EP) is used as the evolutionary optimiser while WARGUS is used as the RTS gaming environment. Evolution of the military unit combinations is conducted online, which means that optimisation is taking place while a particular round of the RTS game is still in progress. Empirical tests show that the online evolution of military unit combination strategies is possible using EP and was able to mount successful offensive campaigns on a reliable basis against three respective built-in, human-crafted AI strategies provided in WARGUS.

Parameters for Dose Matrix Warping in Patient-Specific Quality Assurance of Radiotherapy Dose Distributions applications modalities in radiation oncology, such as intensity-modulated radiation therapy (IMRT), necessitates the measurement of the delivered dose distribution, and the subsequent comparison of the measured dose distribution with that calculated by the treatment planning software. The degree to which the calculated dose distribution is reproduced upon delivery is an indication that the treatment received by the patient is acceptable. A new method for the comparison between the planned and delivered dose distributions is introduced; it assesses the agreement between planar two-dimensional dose distributions. The method uses an evolutionary algorithm to optimise the parameters of the affine transformation, consisting of translation, rotation, and dilation (or erosion), that will warp the measured dose distribution to the planned dose distribution. The deviation of the composite transformation matrix from the identity matrix is an indication of an average geometrical error in the delivered dose distribution, and represents a systematic error in dose delivery. The residual errors in radiation dose at specific points are local errors in dose delivery. The method was applied to IMRT fields consisting of horizontal intensity bands. Analysis shows the method to be a promising tool for patient-specific quality assurance.

hyper-heuristics successful applications, has lambda as the only parameter to tune. There has been no attempt to automatically tune this parameter, resulting in a parameterless GLS. Such a result is a very practical objective to facilitate the use of meta-heuristics for end-users (e.g. practitioners and researchers). In this paper, we propose a novel parameter tuning approach by using Genetic Programming (GP). GP is employed to evolve an optimal formula that GLS can use to dynamically compute lambda as a function of instance-dependent characteristics. Computational experiments on the travelling salesman problem demonstrate the feasibility and effectiveness of this approach, producing parameterless formulae with which the performance of GLS is competitive (if not better) than the standard GLS.

in simulated robot teams. The first method evolves controllers with fixed topologies and adapts team size as a function of task complexity. The second method evolves controller topology as a function of task complexity, but keeps team sizes constant. These methods are: Collective Neuro-Evolution 2 (CONE-2), and Neuro-Evolution for Augmenting Topologies (NEAT). CONE-2 and NEAT are comparatively tested in a collective construction task. The goal is to ascertain the most appropriate controller evolution method for adapting teams to solve a collective construction task, with varying cooperative behaviour requirements. Results indicate that CONE-2 is most effective at adapting controllers as the complexity of the task increases. In environments where multiple forms of cooperative behaviour are required, CONE-2 evolves teams with a higher average task performance. CONE-2 is demonstrated as being effective at evolving behavioural heterogeneity in teams, which results in a higher team fitness, comparative to NEAT evolved teams, in environments that require cooperation.

Using SVM and Random Forests combinatorial optimisation. Reducing the dimensions helps in improving the overall analysis and classification performance. We propose two hybrid techniques, Biogeography - based optimisation - Random Forests (BBO - RF) and BBO - SVM (Support Vector Machines) with gene ranking as a heuristic, for microarray gene expression analysis. This heuristic is obtained from information gain filter ranking procedure. The BBO algorithm generates a population of candidate subset of genes, as part of an ecosystem of habitats, and employs the migration and mutation processes across multiple generations of the population to improve the classification accuracy. The fitness of each gene subset is assessed by the classifiers - SVM and Random Forests. The performances

of these hybrid techniques are evaluated on three cancer gene expression datasets retrieved from the Kent Ridge Biomedical datasets collection and the libSVM data repository. Our results demonstrate that genes selected by the proposed techniques yield classification accuracies comparable to previously reported algorithms.

Planning multiobjective combinatorial optimisation problem. Metaheuristics showed success in solving many hard optimisation problems and recently many efforts have been directed to hybridised elements from different metaheuristics and search methods. The hybridising of genetic algorithms and local search methods proved to be successful in many domains. In this paper we present a genetic local search algorithm for solving the multiobjective time-dependent route planning problem taking the multiobjective route planning in dynamic multihop ridesharing as an example problem. The behaviour of the proposed algorithm is compared, on two problem instances using a set of widely used quality indicators, with the behaviour of a genetic algorithm proposed for solving the same problem. Experimentation results indicated that the proposed algorithm outperforms the genetic algorithm regarding all quality indicators.

using Evolutionary Strategy (IEEE-CEC), Engineering applications, Real-world applications important research problem for the advancement of distributed power systems. This paper presents detail studies on optimal sizing of DER for integrated microgrids using Evolutionary Strategy (ES). Integrated microgrid is an innovative architecture in distributed power systems, in which several microgrids are interconnected with each other for superior control and management of the distributed power systems. Right coordination among DER in microgrids, and proper harmony among the microgrids and the main distribution grid are critical challenges. Types of DER and capacities of them are needed to optimise such that proposed integrated microgrid provides reliable supply of energy at cheap cost. In this research, the problem is formulated as a nonlinear mixed-integer minimisation problem which minimises capital and annual operational cost of DER subject to a variety of system and unit constraints. Evolutionary strategy was developed for solving the minimisation problem. The proposed methodology was used to design integrated microgrids for A*Star IEDS (Intelligent Energy Distribution System) project. The design results have shown that the proposed methodology provides excellent convergence and feasible optimum solution.

Numerical optimisation. implementations of digital fountain codes. Performance of these rate less forward erasure correction codes is determined mainly by the degree distributions of their encoded symbols. Although the asymptotic behaviours of LT codes with large (>10^5) symbol blocks have been deduced analytically, a proficient method for finding the optimal degree distributions of short length (<10^3) LT codes is still absent. In this paper, we propose a practical approach to employ evolution strategies in finding the degree distributions of optimal short-length LT codes for different applications. Our approach begins with the development of a new performance model for LT codes based on three measurements: coding overhead, failure ratio and failure occurrence probability. Three evolution strategies (DE, CMA-ES and NES) were then employed to minimise these performance measurements separately with careful design of fitness functions and necessary transformations of decision variables. Throughout the evolution process, the performance of individual LT code in the population was evaluated with numerical simulations. Our experiments showed that the optimal degree distributions can be found using all three evolution strategies but with different convergence rates and the performance measurements of these optimised codes are all distributed on a smooth and convex surface.

classification in Brain Computer Interface (IEEE-CEC) classifiers to learn the difference of various classes in the underlying pattern in the signal. This paper investigates several evolutionary algorithms used to reduce the dimensionality of the data. The study presents electrode and feature reduction methods based on Genetic Algorithms (GA) and Particle Swarm Optimisation (PSO). Evolution-based methods are used to generate a set of indexes presenting either electrode seats or feature points that maximises the output of a weak classifier. The results are interpreted based on the dimensionality reduction achieved, the significance of the lost accuracy, and the possibility of improving the accuracy by passing the chosen electrode/feature sets to alternative classifiers.

distribution algorithms originated from early attempts to simulate the behaviour of birds looking for food. Estimation of distributions algorithms (EDAs) are a class of evolutionary algorithms that build and maintain a probabilistic model capturing the search space characteristics and continuously use this model to generate new individuals. In this work, we propose a new PSO and EDA hybrid algorithm that uses the particles' distribution in the search space in order to adjust the search space

bounds, hence, restricting the particles movement as well as their allowable maximum velocity. The algorithms is augmented with a mechanism to overcome premature convergence and escape local minima. The algorithm is compared to the standard PSO algorithm using a suite of well-known benchmark optimisation functions. Experimental results show that the proposed algorithm has a promising performance.

Humanoid Robots posture controller to generate an optimal trajectory of humanoid robots against external disturbance using an iterative linear quadratic regulator (ILQR) and concurrently optimise multiple performance criteria. As the dimensionality of nonlinear system increases, it is difficult to find the weighting matrices of cost function in ILQR. In the proposed method, this problem is solved by employing a multi-objective quantum-inspired evolutionary algorithm (MQEA) to obtain nondominated solutions of the weighting matrices generating various optimal trajectories that satisfy multiple performance criteria. Among numerous nondominated solutions generated from MQEA, fuzzy measure and fuzzy integral are employed for global evaluation by integrating the partial evaluation of each of them over criteria with respect to user's degree of consideration for each criterion. The effectiveness of the proposed method is verified by computer simulations for the problem of balancing the posture of a humanoid robot against external impulse force, where the robot is modelled by a four-link inverted pendulum.

Structure Prediction protein structure prediction (PSP) is carried out. However, experimental PSP methods, such as X-ray crystallography and Nuclear Magnetic Resonance (NMR), can be time-consuming and inaccurate. This has given rise to numerous computational PSP approaches to try and elicit a protein's three-dimensional conformation. A popular PSP search strategy is Genetic Algorithms (GA). GAs allow for a generic search approach, which can provide a generic improvement to alleviate the need to redefine the search strategies for separate sequences. Though GA's working principles are remarkable, a serious problem that is inherent in the GA search process is the growth of twins or identical chromosomes. Therefore, enhanced twin removal strategies are crucial for any GA search solving hard-optimisation problems like PSP. In this paper we explain our high-resolution GA feature-based resampling PSP approach and propose a twin removal strategy to further enhance its prediction accuracy. This includes investigating the optimal chromosome correlation factor (CCF) for our approach and defining a pre-built structure library for twin removal. We have also compared our GA approach with the popular Monte Carlo (MC) method for PSP. Our results indicate that out of all the CCF values we tested a CCF value of 0.8 provided the best level of diversity within our GA population. It also generated, on average, more native-like structures than any of the other CCF values, and clearly demonstrated that twin removal is needed in PSP when using GAs to obtain more accurate results.

Constrained Multi-Objective Optimization Problems multi-objective optimisation problems. This requires an optimisation algorithm not only to find the global optimal solutions under a specific environment but also to track the trajectory of the varying optima over dynamic environments. To address this requirement, a hyper rectangle search based particle swarm algorithm is proposed for such problems. This algorithm employs a hyper rectangle search to predict the optimal solutions (in variable space) of the next time step. Then, a PSO based crossover operator is used to deal with all kinds of constraints appearing in the problems when the time step (environment) is fixed. This algorithm is tested and compared with two well known algorithms on a set of benchmarks. The results show that the proposed algorithm can effectively track the varying Pareto fronts over time.

Based on Sleep Apnea Detection adults and has several short term and long term bad side effects on health. Sleep apnea (SA) is the most important and common component of sleep disorders. This paper presents an automatic approach for detecting apnea events by using few bio-singles that are related to breathe defect. This work uses only air flow, thoracic and abdominal respiratory movement as input. The proposed algorithm consists of three main parts which are signal segmentation, feature generation and classification. A new proposed segmentation method intelligently segments the input signals for further classification, then features are generated for each segment by wavelet packet coefficients and also original signals. In classification phase a unique parallel PSO-SVM algorithm is investigated. PSO used to tune SVM parameters, and also data reduction. Proposed parallel structure used to help PSO to search space more efficiently, also avoiding fast convergence and local optimal results that are common problem in similar parallel algorithms. Obtained results demonstrate that the proposed method is effective and robust in sleep apnea detection and statistical tests on the results shown superiority of it versus previous methods even with more input signals, and also versus single PSO-SVM. Using fewer

signals means more comfortable to subject and also, reduction of cost during recording the data.

navigation of a mobile robot. Several research initiatives, aiming at providing optimised solutions to this problem, have emerged. Ant Colony Optimisation (ACO) and Genetic Algorithms (GA) are the two most widely used heuristics that have shown their effectiveness in solving such a problem. This paper presents, smartPATH, a new hybrid ACO-GA algorithm to solve the global robot path planning problem. The algorithm consists of a combination of an improved ACO algorithm (IACO) for efficient and fast path selection, and a modified crossover operator for avoiding falling into a local minimum. Our system model incorporates a Wireless Sensor Network (WSN) infrastructure to support the robot navigation,where sensor nodes are used as signposts that help locating the mobile robot, and guide it towards the target location. We found out smartPATH outperforms classical ACO (CACO) and GA algorithms (as defined in the literature without modification)for solving the path planning problem both and Bellman-Ford shortest path method. We demonstrate also that smartPATH reduces the execution time up to 64.9percent in comparison with Bellman-Ford exact method and improves the solution quality up to 48.3percent in comparison with CACO.

Multi-Objective Optimization innovative ways to increase airspace capacity while maintaining safety. A key safety indicator for an airspace is its Collision Risk estimate, which is compared against a Target Level of Safety (TLS) to provide a quantitative basis for judging the safety of operations in an airspace. However this quantitative value does not give an insight into the overall collision risk picture for an airspace, and how the risk changes given the interaction of a multitude of factors such as sector/traffic characteristics and controllers actions for flow management. In this paper, we propose an evolutionary framework with multi-objective optimisation to evolve collision risk of air traffic scenarios. We attempt to identify, through evolutionary mechanism, the flight events resulting from ATC actions that can lead to higher collision risks, thereby identifying the contributing factors or the events leading to collision risk. Computational experiments were conducted in an hi-fidelity air traffic simulation environment with collision risk model. Results indicate that risk-free traffic scenarios having collision risk below TLS can become risk-prone by few flight events, with Climb and Turn manoeuvres, specifically during entering and exiting a sector, contributing significantly to increased collision risk.

Biogeography Based Optimization Artificial ecology and artificial life areas where human hands are inaccessible. Digital Imagery brings the virtual image of a desired location, which requires some pre-processing to bring the view to an optimal level. Accuracy level in image classification is assumed on the categorisation of the pixel into one of the several land cover classes. When the recognition of pixel accounts for two different classes at the same time, the resulting pixel is categorised as a mixed pixel. This paper proposes a novel approach by clustering the dataset of mixed pixel and thereafter implementing fusion of Ant Colony Optimisation (ACO) and Biogeography Based Optimisation (BBO) thereby resolving the problem of mixed pixels.

Graphics Hardware (IEEE-CEC), CIGPU-2012, Parallel and distributed algorithms exploiting a multi-GPU cluster. The proposed implementation employs an island-based genetic algorithm where every GPU evolves a single island. The individuals are processed by CUDA warps, which enables the solution of large knapsack instances and eliminates undesirable thread divergence. The MPI interface is used to exchange genetic material among isolated islands and collect statistical data. The characteristics of the proposed GAs are investigated on a two-node cluster composed of 14 Fermi GPUs and 4 six-core Intel Xeon processors. The overall GPU performance of the proposed GA reaches 5.67 TFLOPS.

Search Evolutionary Multiobjective Optimisation strategy (MOEA/S-DE) is proposed in this paper, in which the objective space is divided into some subregions and then independently optimise each subregion. An external set is introduced for each subregion to save some individuals ever found in this subregion. An alternative of mutation operators based the idea of direct simplex method of mathematical programming are proposed: local and global mutation operator. The local mutation operator is applied to improve the local search performance of the algorithm and the global mutation operator to explore a wider area. Additionally, a reusing strategy of difference vector also is proposed. It reuses the difference vector of the better individuals according to a given probability. Compared with traditional DE, the crossover operator also is improved. In order to demonstrate the performance of the proposed algorithm, it is compared with the MOEA/D-DE and the hybrid-NSGA-II-DE. The result indicates that the proposed algorithm is efficient.

algorithms based on recent theoretical advances that have established connections between bilevel optimization and multiobjective optimization. In the proposed procedure, a new algorithm is defined

by integrating an evolutionary multiobjective optimization algorithm with a partial order that is compatible with bilevel optimization. The advantages of the procedure include the ability to harness the methodology of evolutionary multiobjective optimization for bilevel optimization and to systematically develop new algorithms for single-objective and multiobjective bilevel optimization. No regularity assumptions are used, which ensures maximal applicability of the optimization algorithms constructed by the procedure. The necessary theoretical foundation is developed and the steps of the procedure are illustrated with an example.

(IEEE-CEC) energy at the location of its consumption, independently from the supply grid, and exploiting renewable energy sources, such as sunlight and wind. Rapidly changing conditions on energy markets and strengthening environmental requirements make alternative energy supply systems more and more favoured. However, designing such systems is a hard optimization problem because of numerous decision variables, conflicting criteria, and complex evaluation of the candidate designs. There are reports on techno-economic optimization of alternative energy supply systems in the literature that search for optimal system configurations maximising technical performance and minimising the overall costs. The authors employ stochastic optimization methods integrated with numerical models of the energy supply systems, and handle multiobjective optimization problems in the single objective manner through the weighted sum approach or transformation of selected criteria into constraints. This paper describes a Pareto multiobjective approach to techno-economic optimization of an alternative energy supply system based on differential evolution for multiobjective optimization. The paper reviews the related work, introduces the applied methodology and the considered problem, describes the experimental setup and the performed numerical experiments, and reports on the optimization results.

of evolution to find excellent special-purpose solutions to a problem means that, in some cases, evolutionary techniques generalise poorly. In this study we demonstrate a system that generalises apoptotic cellular automata rules from a small evaluation arena to a larger one. The generalisation preserves many of the features of the cellular automata while increasing the size of the automata's time history. The fidelity of the appearance of the generalised rules to their progenitors is high but varies for different progenitors. The generalisation is attained by use of single parent techniques. These techniques employ a set of one or more immortal progenitors that are available for crossover but do not otherwise participate in the population. The form of single parent technique used here is novel and the study includes parameter tuning for its use.

Evolutionary Algorithm objective optimization problem with system operation cost as the only objective. This paper presents multi-objectivization of short-term unit commitment problem in uncertain environment by considering reliability as an additional objective along with economic objective. The uncertainties occurring due to unit outage and load forecast error are incorporated using loss of load probability (LOLP) and expected unserved energy (EUE) reliability indices. The multi-objectivized unit commitment problem in uncertain environment is solved using our earlier proposed multi-objective evolutionary algorithm [1]. Simulations are performed on a test system of 26 thermal generating units and the results obtained are benchmarked against the study [2] where the unit commitment problem was solved as a reliability-constrained single-objective optimization problem. The simulation results demonstrate that the proposed multi-objectivized approach can find solutions with considerably lower cost than those obtained in the benchmark. Further, the efficiency and consistency of the proposed algorithm for multi-objectivized unit commitment problem is demonstrated by quantitative performance assessment using hypervolume indicator.

Real-world applications during the ROADEF 2005 Challenge, has been tackled by organising objectives in a hierarchy. However from a decision-making viewpoint it would be interesting to tackle this problem in a Pareto sense. Indeed, tackling the problem in Pareto sense can offer greater latitude to a manager by presenting him several alternative solutions. In this paper, we suggest to adapt the GISMOO algorithm to solve the industrial car sequencing problem. A comparison of the performance is carried out using well-known published algorithms and proves an advantage for GISMOO. As well, we aim to demonstrate the relevance of handling applied problems such as the industrial car sequencing problem using a Pareto multi-objective approach

Optimization-Inspired Small-World Network using a novel Small-World (SW) network architecture. An emergent method that creates a new type of Small-World network with less average path-length than that obtained with conventional small-world networks is presented. This method is inspired from an Ant-Colony Optimisation (ACO) algorithm. The resultant network architecture becomes a multi-star network, which yields a large clustering coefficient and the shortest average path-length

among the conventional complex networks such as the Watts-Strogatz and Barabasi-Albert models etc., from both a theoretical and an experimental analysis of the properties of those networks. Given the advantageous properties of the multi-star network in real-world applications, it could be used to design a new generation global airline network superseding in terms of efficiency and convenience the current, conventional airline network owing to fewer transits and a shorter cruising distance on average from any starting point to any destination on Earth. This will be beneficial not only both to travellers and airline companies, but will also contribute to the reduction of greenhouse gases such as carbon dioxide (CO2) in the near future, while enhancing communications and transportation worldwide.

Optimization Problems quantum computing. It attempts to resolve ordering combinatorial optimization problems, the most well known of which is the travelling salesman problem (TSP). Classic and quantum-inspired genetic algorithms based on binary representations have been previously used to solve combinatorial optimization problems. However, for ordering combinatorial optimization problems, order-based genetic algorithms are more adequate than those with binary representation, since a specialised crossover process can be employed in order to always generate feasible solutions. Traditional order-based genetic algorithms have already been applied to ordering combinatorial optimization problems but few quantum-inspired genetic algorithms have been proposed. The algorithm presented in this paper contributes to the quantum-inspired genetic approach to solve ordering combinatorial optimization problems. The performance of the proposed algorithm is compared with one order-based genetic algorithm using uniform crossover. In all cases considered, the results obtained by applying the proposed algorithm to the TSP were better, both in terms of processing times and in terms of the quality of the solutions obtained, than those obtained with order-based genetic algorithms.

Combinatorial Optimisation Problems docking prediction is one of the major problems in designing new drugs, many researchers keep looking for a high performance search algorithm to find the workable directions to drug design as well as a simulator platform being able to test and verify the new drugs. In this paper, an improved version of Lamarckian genetic algorithm (ILGA) is first presented for enhancing the performance of LGA by using pattern reduction to reduce the computation cost and using tabu search to increase the search diversity to further find the better results. In addition, the proposed algorithm is also applied to a well-known simulator platform (AutoDock) to evaluate the performance of the proposed algorithm. The simulation results show that the proposed algorithm can enhance the performance of ILGA in terms of convergence performance especially for highly flexible ligands.

Cooperative Coevolutionary Evolutionary Algorithms computation theory conventional Evolutionary Algorithm: it implements the idea of divide and conquer by separating the whole set of variables into several subsets (group), and evolve each subset independently with a certain optimiser. How to group the variables effectively have been studied by several researchers. Quite a number of variable grouping strategies have been proposed, in most of which, the correlation among variables is widely considered as the most important information for guiding grouping, although its legitimacy has not been investigated comprehensively. In this paper an empirical analysis is conducted to testify the legitimacy of assumption that the correlation among variables is the most important measure for variable grouping. The experiment results show that in some situation, the performance of random grouping is better than that of grouping based on the correct correlation knowledge. Then the effect of variables' correlation in problem decomposition is discussed.

the large computational time is the major drawback to use this method in real time application. Using the concepts of replication and massive parallelism operations, the DNA computing algorithm can efficiently reduce the computational time of the template matching method. The emphasis of this research has been given in two objectives namely development of a generic DNA computing algorithm for object identification based on the theme of the template matching technique and application of this algorithm for recyclable waste paper sorting. The achieved classification success rates are 92percent, 90percent, and 93percent with template size 5 X 5 pixels for white paper, old newsprint paper and old corrugated cardboard, respectively.

of the best performing Ant Colony Optimisation algorithms. Standard implementation uses n x n matrix of artificial pheromone to solve the Travelling Salesman Problem, where n is the number of cities. We show, that only small fraction of values in the pheromone matrix is changed from a global value and so the matrix can be replaced by an array of hash tables in order to reduce the memory complexity. This improvement is very useful in case of Parallelization on multi-core architectures, where frequent transfers of random parts of matrices cause radical slowdown. Also it enables algorithm to be

competitive with others when solving large instances.

projection technique for face recognition. In subspace methods like PCA, feature selection is fundamental to obtain better face recognition. However, the problem of finding a subset of features from a high dimensional feature set is NP-hard. Therefore, to solve the feature selection problem, heuristic methods such as evolutionary algorithms are gaining importance. In many face recognition applications, due to the small sample size (SSS) problem, it is difficult to construct a single strong classifier. Recently, ensemble learning in face recognition is gaining significance due to its ability to overcome the SSS problem. In this paper, the NP-hard problem of finding the best subset of the extracted PCA features for face recognition is solved by using the differential evolution (DE) algorithm and is referred to as FS-DE. The feature subset is obtained by maximising the class separation in the training data. We also present an ensemble based approach for face recognition (En-FR), where different subsets of PCA features are obtained by maximising the distance between a subset of classes of the training data instead of whole classes. The subsets of the classes are obtained by bagging and overlap each other. Each subset of the PCA features selected is used for face recognition and all the outputs are combined by a simple majority voting. The proposed algorithms, FS- DE and En-FR, are evaluated on four well-known face databases and the performance is compared with the PCA and Fisher's LDA algorithms.

Chromosomes intervention principle with Estimation of Distribution Algorithms (EDA), is designed to solve optimal control problems where the number of interventions is an element of solution fitness. This paper applies it to a network routing problem and in doing so adapts it to problems involving variable length chromosomes. We show that TEDA can outperform algorithms using standard crossover techniques such as one and two point crossover on this new problem and in doing so we extend the range of problems that TEDA is effective at solving.

Evolutionary Multiobjective Optimisation researchers. In this paper, we discuss a number of viable directions for developing a potential EMO algorithm for many-objective optimization problems. Thereafter, we suggest a reference-point based many-objective NSGA-II (or MO-NSGA-II) that emphasises population members which are non-dominated yet close to a set of well-distributed reference points. The proposed MO-NSGA-II is applied to a number of many-objective test problems having three to 10 objectives (constrained and unconstrained) and compared with a recently suggested EMO algorithm (MOEA/D). The results reveal difficulties of MOEA/D in solving large-sized and differently-scaled problems, whereas MO-NSGA-II is reported to show a desirable performance on all test-problems used in this study. Further investigations are needed to test MO-NSGA-II's full potential.

Optimization in Dynamic Environments landscape is time dependent and the optima change over time such as dynamic economic modelling, dynamic resource scheduling, and dynamic vehicle routing. Such problems challenge traditional optimization methods as well as conventional evolutionary optimization algorithms. For such environments, optimization algorithms not only have to find the global optimum but also closely track its trajectory. In this paper, we propose a collaborative version of cellular PSO, named Two Phased cellular PSO to address dynamic optimization problems. The proposed algorithm introduces two search phases in order to create a more efficient balance between exploration and exploitation in cellular PSO. The conventional PSO in cellular PSO is replaced by a proposed PSO to increase the exploration capability and an exploitation phase is added to increase exploitation is the promising cells. Moreover, the cell capacity threshold which is a key parameter of cellular PSO is eliminated due to these modifications. To demonstrate the performance and robustness of the proposed algorithm, it is evaluated in various dynamic environment modelled by Moving Peaks Benchmark. The results show that for all the experimented dynamic environments, TP-CPSO outperforms all compared algorithms including cellular PSO.

Convergence, scalability and complexity analysis D-PSO) systems which does not contain any stochastic factors. The found 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 the D-PSO and its performance, we pay attention to the degree and the average distance used in graph theory. We consider the two cases where the D-PSO has an extended cycle structure and a Small World network structure. Our numerical simulation results indicates the searching performance of the D-PSO is depended on the average distance of the node. Especially, the long average distance exerts the search performance

on the D-PSO. We confirm that the search performance properties of the D-PSO and the conventional stochastic PSO are completely different to the average distance. The search performance of the D-PSO is improved according to the average distance. On the other hand, the search performance of the conventional stochastic PSO is deteriorated according to the average distance. We consider that the slow transmission of the beneficial information leads to the diversification of the particles of the D-PSO. Also, we clarify the small perturbation of the random range of the stochastic PSO is important.

Modified Version of Multi-criteria VEDEPSO Optimizer task. The designed words should be as unique as possible, thermodynamically stable, non-self hybridised, non-cross hybridised with others and have good chemical properties. In this paper, the DNA words designing approach implied concurrent minimisation of four objective functions, H-measure, similarity, hairpin and continuity. The designations is subjected to a predefine range of melting temperature and GC-content. A novel multi-population optimiser, M-VEDEPSO, is employed to design sets of DNA strands. The algorithm runs for 10 times and as a result, each population has lower average fitness values compared to the fitness values obtained using the conventional VEDEPSO algorithm. The results obtained from the algorithm are indicated by 12 randomly selected non-dominated particles/individuals. These solutions are obtained via Pareto dominance concepts.

landscaping. iPresage relies on sophisticated text mining, statistical machine learning and computational intelligence algorithms to allow analysts to mine large patent databases and evaluate white spaces and temporal trends. This paper describes iPresage algorithms in detail and showcases iPresage functionality, using an illustrative example.

Representations of EEG Signals and hybrid algorithms, Classification, clustering, data analysis and data mining pursuit (NMP), that was designed to search for sparse signal representations. This algorithm combines global sampling based on a Grassmannian dictionary of atomic signals with local search using natural gradient decent in the signal parameter space. Performance of the algorithm was demonstrated by analysing Jung and Makig's ERP data sets. It can obtain unbiased sparse representations of EEG signals in far less iteration than its predecessor, the stochastic matching pursuit (SMP).

exploitation can obtain very good results in continuous optimisation. That implies the evolutionary algorithm component should be focused in exploring the search space while the local search method exploits the achieved solutions. In a previous work, it was proposed a memetic algorithm, MA-LSCh-CMA, that was able to work with a local search method, CMA-ES, with a great exploitation factor, but without a mechanism to maintain diversity and avoid competition between the evolutionary algorithm and CMA-ES. In this work, we propose a variation of this algorithm, called RMA-LSCh-CMA, adding a niching strategy that divide the domain search in equal hypercubes. The experimental results obtained show that the new version is statistically better than the previous one and is very competitive in comparisons with the state-of-the-art algorithm IPOP-CMA-ES, obtaining equivalent results on the medium and higher dimensions, although slightly better in the higher dimension.

(IEEE-CEC) pathogens inspired people on the development of artificial immune systems. Designed to simulate the functionalities of biological immune systems, artificial immune systems are suggested to be mainly applied in the domain of computer security. In this paper, we propose an artificial immune system for phishing detection. The system is to detect phishing emails through memory detectors and immature detectors. The memory detectors are generated from the training data set, which, in turn, is the phishing emails previously seen by the system. The immature detectors are reproduced through the system's mutation process. To the best of our knowledge, this is the first time such a system is ever proposed. We believe that the system is more adaptive than any other existing phishing detection techniques.

Evolutionary Robotics understand the mechanisms underlying this process, many hypotheses have been proposed and tested. Lamarck formed the hypothesis Inheritance of acquired characteristics, which states that offspring inherit characters acquired by their parents. However, this hypothesis has now been rejected in the field of genetics. Baldwin offered an explanation for observations of inheritance of acquired characters, despite the fact that they are not inherited; an idea referred to as the Baldwin effect.To verify the Baldwin effect, many studies have been conducted and various numerical simulations have been demonstrated. However, in conventional simulations, the real world is modelled as a simple environment and various properties of the real world are neglected. As a result, effects of universal properties of the real world in evolution have not been discussed. In this study, we considered that universal properties of the real world play important roles in the Baldwin effect. We

used the task of escaping from a hunter, and evolved a fugitive agent in a simulated world in which physical properties are used. We investigated the roles of the real-world properties, through conducted simulations, revealed that a fugitive agent was able to reduce learning time by using the real-world properties, thus supporting the occurrence of the Baldwin effect.

metaheuristics and hyper-heuristics interested in combining them for taking advantage of their diversity. We propose to use the algorithm portfolio model of execution. In this model, we have multiple resources on which the candidate heuristics can be executed. An instance is solved through a concurrent execution of heuristics (each on a fraction of resources) that is stopped as soon as one of them completes its execution. The efficiency of this model depends among other things of the resource sharing adopted in a concurrent execution. In most algorithm portfolio studies, the resources fraction of a heuristic is fixed. In this paper, we consider malleable algorithm portfolio. In this portfolio model, the fraction of resources of a heuristic can be changed during its execution. We extend the computational model proposed in [1] to formalise the problem of resource sharing construction in malleable portfolio. We then propose an efficient algorithm based on the combination of two guaranteed approximation algorithms for solving it. Finally, we evaluate the proposed algorithm with multiple simulations on a database of SAT solvers. The obtained results show that even in considering that the resource allocation of a heuristic can just be changed once, malleable allocations in comparison to static ones lead to an improvement of the spent time for solving an instance in algorithm portfolio.

Network Real-Time Kinematic Intelligence in Communications and Networking (IEEE-CEC) (Global Positioning System) or more generally on GNSS (Global Navigation Satellite System) observations to achieve centimeter-level accuracy positioning in real time. It is enabled by a network of Continuously Operating Reference Stations (CORS). CORS placement is an important problem in the design of network RTK as it directly affects not only the installation and running costs of the network RTK, but also the Quality of Service (QoS) provided by the network RTK. In our preliminary research on the CORS placement, we proposed a polynomial heuristic algorithm for a so-called location-based CORS placement problem. From a computational point of view, the location-based CORS placement is a large-scale combinatorial optimization problem. Thus, although the heuristic algorithm is efficient in computation time it may not be able to find an optimal or near optimal solution. Aiming at improving the quality of solutions, this paper proposes a repairing genetic algorithm (RGA) for the location-based CORS placement problem. The RGA has been implemented and compared to the heuristic algorithm by experiments. Experimental results have shown that the RGA produces better quality of solutions than the heuristic algorithm.

GA the efficiency of the hybrid Taguchi genetic algorithm and aims to provide guidelines for algorithm's usage in continuous optimization. We examine the hybrid Taguchi genetic algorithm (HTGA) with 8 different crossover operators and apply it to 15 benchmark numerical optimization problems. The implementation uses binary representation which maps chromosomes to values in real domain with arbitrary precision. Different crossover operators are used with the HTGA and a detailed statistical analysis is performed to evaluate their performance. The results indicate that the HTGA obtains better results with crossover operators different than the ones commonly reported in literature.

Multi-robot Motion Planning Bacterial Foraging Algorithm (BFOA) in the existing Improved Harmony Search (IHS) algorithm. Extensive computer simulations with CEC-2005 benchmark functions reveal that the proposed algorithm outperforms the existing one with respect to accuracy in determining the optima. The proposed algorithm has successfully been implemented for multi-robot motion planning application. Performance has been studied using the proposed IHS-BFO algorithm and compared with existing IHS and Particle Swarm Optimisation (PSO) algorithm.

Evolutionary Algorithms optimization problems with a small number of objectives, two or three in general. However, when encounter problems with many objectives (more than five), nearly all algorithms performs poorly because of loss of selection pressure in fitness evaluation solely based upon Pareto domination. In this paper, we introduce a new fitness evaluation mechanism to continuously differentiate solutions into different degrees of optimality beyond the classification of the original Pareto dominance. Here, the concept of fuzzy logic is adopted to define fuzzy-dominated relation. As a case study, the fuzzy concept is incorporated into the NSGA-II, instead of the original Pareto dominance principle. Experimental results show that the proposed method exhibits a better performance in both convergence and diversity than the original NSGA-II for solving many-objective optimization problems. More importantly, it enables a fast convergence process.

Optimization Problems which is able to continuously track a changing optimum over time. In this

paper, we present an ant-colony based algorithm for solving optimization problems with continuous variables, labelled Continuous Differential Ant-Stigmergy Algorithm (CDASA). The CDASA is applied to dynamic optimization problems without any specialised modification to the algorithm. The performance of the CDASA is evaluated on the set of benchmark problems provided for the IEEE Competition on Evolutionary Computation for Dynamic Optimisation Problems (ECDOP-Competition-2012).

data is an extremely challenging process which directly impacts the time that could be spent on activities relevant to software testing. Therefore, various researches related to this area has been carried out. Among the techniques for automatically generating test data, we highlight the use of metaheuristics, a promising area called Search-Based Software Testing (SBST). Thus, the article propose the use of an Elitist Genetic Algorithm (GA) as a tool for generation and selection of test data applied in Mutation Testing for different benchmarks. The results indicate a good performance of the algorithm used in the benchmarks.

Power Distribution Systems Problems, Real-world applications, Engineering applications distribution expansion problem. The design problem is modelled as a mono objective optimization problem in which the objective function is the monetary cost of the network. A new procedure is proposed to perform substation location while the function evaluation is done. Results for a real eight bus energy system are presented.

Scheduling Problem: Application to Maritime Domain Awareness Computation in Scheduling mobile and fixed surveillance assets to a large geographic operation area in order to perform surveillance activities. Finding efficient management solutions should be investigated to optimise assets allocation and tasks achievement. In this paper, we propose to model this optimization problem as a multi-objective, multi-mode assignment and scheduling problem. Resources are to be assigned to accomplish the tasks. Then, surveillance tasks should be scheduled onto successive periods. The problem is designed to consider two conflicting objective functions: manumitting the makespan and minimising the total cost. As the problem is NP-Hard, a bi-colony ant based approach is proposed. The empirical validation is done using a simulation environment Inform Lab. The experimental results show that the computational time remains polynomial with respect to the problem's size.

Discrete and combinatorial optimization. achievement of their objectives. The effect of these uncertainties can be perceived as risk that will be taken. A healthful company have to anticipate undesired events by defining a process for managing risks. Risk management processes are responsible for identifying, analysing and evaluating risky scenarios and whether they should undergo control in order to satisfy a previously defined risk criteria. Risk specialists have to consider, at the same time, many operational aspects (decision variables) and objectives to decide which and when risk treatments have to be executed. In line with that, most companies select risks to be treated by using expertise of human specialists or simple sorting heuristics based on the believed impact. Companies have limited resources (e.g. human and financial resources) and risk treatments have costs which the selection process has to deal with. Aiming to balancing the competition between risk and resource management this paper proposes a new optimization step within the standard risk management methodology created by the International Organisation for Standardisation (a.k.a. ISO). To test the resulted methodology, experiments based on the Non-dominated Sorting Genetic Algorithm (more specifically NSGA-II) were performed aiming to manage risk and resources of a simulated company. Results show us that the proposed approach can deal with multiple conflicting objectives reducing the risk exposure time by selecting risks to be treated according their impact and available resources.

Genetic Network Programming Variable Size Genetic Network Programming (GNPvs) called Subroutine embedded GNPvs (SGNPvs). GNPvs is a general type of GNP, which has a direct graph representation with changeable size. In order to improve the performance of GNPvs, SGNPvs has been proposed, in which a subroutine mechanism has been introduced to GNPvs by module acquisition. In SGNPvs, useful subgraphs are extracted and reused for individuals. Through extracting new subroutines to replace the old subroutines, SGNPvs can evolve the subroutines as well as evolve the individuals. The simulation results verify the performance of SGNPvs on a well-known dynamic multi-agent test bed – Tileworld.

Activation Model compared with the man-made system. These abilities emit a strong attraction to engineers engaged in reliable electronic system design. In the current paper, a bio-inspired approach based on a lateral activation model from biological pattern formation theory is used to design the genotype of a French flag Organism. This lateral activation model represents the inter cellular and intracellular interaction of biochemical substances. The designed French flag organism not only has the

ability to form arbitrary sizes or a French flag pattern, but also exhibit powerful individual adaptability which is different from the adaptability that can be derived from species evolution. Moreover, this French flag organism shows wonderful dissociated-and-reaggregated capacity as hydrae. The current paper shows that designing reliable electronic systems that are similar to an organism is entirely possible through bioinspired approach, and provides a new avenue for future reliable electronic systems design.

Real-world applications solutions for complex problems. However the downside of it is also well known: the evolved solutions are often difficult to understand. This interpretability issue hinders GP to gain acceptance from many application areas. To address this issue in the context of motion detection, GP programs evolved for various detection tasks are analysed in this study. Previous work has shown the capabilities of these evolved motion detectors such as ignoring uninteresting motions, differentiating fast motions from slow motions, identifying genuine motions from a moving background, and handling noises. This study aims to reveal the behaviour of these GP individuals by introducing simplified motion detection tasks. The investigation on these GP motion detectors shows that their good performance is not random. There are contributing characteristics captured by these detectors, of which the behaviours are more or less explainable. This study validates GP as a good approach for motion detection.

Computation its flexibility, interpretability and implicit feature manipulation. There are also disadvantages to the use of GP for classification, including computational cost, bloating and parameter determination. This work analyses how GP-based classifier learning scales with respect to the number of examples in the classification training data set as the number of examples grows, and with respect to the number of features in the classification training data set as the number of features grows. The scalability of GP with respect to the number of examples is studied analytically. The results show that GP scales very well (in linear or close to linear order) with the number of examples in the data set and the upper bound on testing error decreases. The scalability of GP with respect to the number of features is tested experimentally, with results showing that the computations increase exponentially with the number of features.

Control Volumes certain physical aspects of real world objects like e.g. in the automotive or aeronautical domain depends on the efficient interplay of optimization algorithm, evaluation method and shape representation. For the development of complex aerodynamic components, evolutionary algorithms as global stochastic optimization algorithms have been successfully coupled to shape morphing methods. Instead of a direct representation of the shapes' boundary, shape morphing methods like free-form deformation (FFD) apply scalable changes to a baseline prototype using a moderate number of parameters mapped to control point movements. The initial spatial arrangement of the control points influences strongly the design flexibility and the optimization performance in combination with the normal distributed mutation operator in evolutionary optimization algorithms. In the present paper, a method is proposed to support the generation process of initial FFD control volumes which is usually carried out manually in practice. The method is based on the concept of evolvability which is considered as the property of initial control volumes to generate favourable design variations within a moderate number of iterations while avoiding unfeasible mutations. We introduce mathematically translational design variability, mutational design variability and the central robust control volume as key features to compute an evolvable distribution of control points. In target shape matching experiments using an evolutionary strategy, the performance for different configurations of evolvability-tuned initial control volumes is shown empirically.

considering Melody Blocks algorithm and N-gram model considering melody blocks such as In this paper, we propose an automatic composition system using genetic algorithm and N-gram model considering melody blocks such as verse, bridge and chorus. In the proposed system, melody is divided into some blocks such as verse, bridge and chorus, some new melodies are generated using melody feature in each block. The feature on tone and length of sounds in each block of the sample melodies is trained in some N-gram models, and they are used in the calculation of fitness in the melody generation by the genetic algorithm. The tone and length of sounds are expressed as genes, and some melodies similar to the trained sample melodies are generated by genetic algorithm. In the proposed system, the fitness of the gene for each melody block is calculated based on (1) transition of rhythm, (2) transition of tone, (3) transition of tone and length, (4) transition of the number of sounds per bar, (5) similarity of rhythms between phrases, (6) rate of unique sounds of scales, (7) difference between two sounds and (8) length of rests. We carried out a series of computer experiments and confirmed that the some melodies reflecting the feature in each melody block of the trained sample melodies can be generated.

Sensor Networks uncertain environments. yet suitable patterns to adapt to environment changes

dynamically in uncertain environments. Inspired by biological morphogenesis which is guided by gene regulatory networks (GRNs), in this study, we propose a GRN-based approach to self-organisation of mobile sensor networks in dynamic, uncertain environments. Instead of predefining the dynamics of the GRN model like other alternative studies, we aim to evolve the GRN framework to an appropriate structure automatically. Recently biological studies found out that network motifs are simple universal building blocks for most complex networks. Based on this study, the basic idea of the GRN-based approach is as follows: first, some predefined network motifs are employed as the basic building blocks, then an evolutionary algorithm is applied to evolve parameters and the structures of the GRN-based model based on these basic building blocks. Several simulation results have demonstrated that the proposed bio-inspired model is efficient for the self-organisation of mobile sensor networks and robust to environmental changes in complex environments.

a population of current positions and a population of personal best attractors. In genetic algorithms, crossover is applied after selection, the goal is to create a new offspring solution using components from the best available solutions. In a particle swarm, the best available solutions are in the population of personal best attractors. Compared to standard particle swarm optimization, a modified version which periodically creates particle positions by crossing the personal best positions can achieve large improvements. These improvements are most consistent on multi-modal search spaces where the new crossover solutions may help the search process escape from local optima.

optimization. community, considering that one or more constraints need to be satisfied in most real life optimization problems. Recently, we proposed a Most Probable Point based repair approach for handling equality constraints in Single- objective and Multi-objective optimization problems. In this work, we demonstrate the application of the repair approach to handle active inequality constraints. We show that the repair mechanism, which has so far been strictly applied to the domain of equality constraint handling can be used to obtain better results with faster convergence even in inequality constrained problems. We take up a number of standard Single-objective test problems having one or more active inequality constraints for our study. The applicability of the proposed procedure is demonstrated on a well studied Engineering design optimization problem. The present study contributes to the scarce body of literature available on repair mechanisms in inequality constraint handling and hence should motivate further research in this direction.

Optimization Numerical optimization. concept and main ideas of the coevolution of symbiotic species in natural ecosystems. A novel approach called multi-hive artificial bee colony for constrained multi-objective optimization (MHABC-CMO) is proposed based on this model. A novel information transfer strategy among multiple swarms and division operator are proposed in MHABC-CMO to tie it closer to natural evolution, as well as improve the robustness of the algorithm. Simulation experiment of MHABC-CMO on a set of benchmark test functions are compared with other nature inspired techniques which includes multi-objective artificial bee colony (MOABC), nondominated sorting genetic algorithm II (NSGA II) and multi-objective particle swarm optimization (MOPSO). The numerical results demonstrate MHABC-CMO approach is a powerful search and optimization technique for constrained multi-objective optimization.

Particle Swarm Optimization scalability and complexity analysis due to improper search information propagation. Fast propagation of search information will lead particles get clustered together quickly. Determining a proper search information propagation mechanism is important in optimization algorithms to balance between exploration and exploitation. In this paper, we attempt to figure out the relationship between search information propagation and the population diversity change. Firstly, we analyse the different characteristics of search information propagation in PSO with four kinds of topologies: star, ring, four clusters, and Von Neumann. Secondly, population diversities of PSO, which include position diversity, velocity diversity, and cognitive diversity, are used to monitor particles' search during optimization process. Position diversity, velocity diversity, and cognitive diversity, represent distributions of current solutions, particles' moving potential, and particles' moving target, respectively. From the observation of population diversities, the effect of search information propagation on PSO's optimization performance is discussed at last.

Adaptation Strategy dynamic programming and reinforcement learning process can improve the overall performance of evolutionary algorithms (EAs). In this paper, a novel maturity-based adaptation strategy for EAs is proposed. During the search process, a maturity degree of the population is calculated based on both the population distribution in the search space and that in the fitness space. According to the maturity degree, four evolution states of EAs are defined by a set of thresholds. As

both the convergence of the genotypes (reflected by the geographical distance among the individuals) and that of the phenotypes (shown by the differentiation over individuals' fitness values) are taken into consideration, the estimation of the evolution state is very comprehensive. Then, a set of adaptation rules is applied to adapt the parameters and operators of EAs according to the maturity degree and evolution state. Implemented on genetic algorithm (GA), the probabilities of crossover and mutation are tuned to fulfil the current evolution requirement of the population. Meanwhile, a novel allele gene-based mutation scheme and the traditional mutation are alternately executed. Experimental results on eight benchmark functions show that the proposed maturity-based adaptation strategy can bring significant improvements in search speed, solution accuracy and robustness.

Image Digital Radiographs radiographic images obtained by the Double Wall Double Image (DWDI) technique. Such task constitutes an essential step for several high level processes, such as fully automatic flaw identification on welded joints. Sets of sample pixels, corresponding to candidate solutions provided by a genetic algorithm (GA), are compared to pre-defined synthetic weld bead and pipe models in an image matching procedure. The fitness of each set (individual) is evaluated based on a linear combination of its genotype (evaluated by a heuristic function) and phenotype. The evolutionary process automatically selects the best individual in the population and, thus, provides information such as position, orientation and dimension of the detected object. The proposed approach successfully detects pipes and weld beads in radiographic images of different complexities, encouraging future works.

dynamic programming and reinforcement learning problems under uncertainty. Reinforcement Learning (RL) techniques provide a powerful solution for it. An agent used by RL interacts with a dynamic environment and finds a policy through a reward function, without using target labels like Supervised Learning (SL). However, one fundamental assumption of existing RL algorithms is that reward function, the most succinct representation of the designer's intension, needs to be provided beforehand. In practice, the reward function can be very hard to specify and exhaustive to tune for large and complex problems, and this inspires the development of Inverse Reinforcement Learning(IRL), an extension of RL, which directly tackles this problem by learning the reward function through expert demonstrations. IRL introduces a new way of learning policies by deriving expert's intensions, in contrast to directly learning policies, which can be redundant and have poor generalisation ability. In this paper, the original IRL algorithms and its close variants, as well as their recent advances are reviewed and compared.

Detecting Landscape Modality successfully applied to optimization problems including non-linear, non-differentiable, non-convex and multimodal functions. There are several mutation strategies such as the best and the rand strategy in DE. It is known that the best strategy is suitable for unimodal problems and the rand strategy is suitable for multimodal problems. However, the landscape of a problem to be optimised is often unknown and the landscape is changing dynamically while the search process proceeds. In this study, we propose a new and simple method that detects the modality of landscape being searched: unimodal or not unimodal. In the method, some points on the line connecting the centroid of search points and the best search point are sampled. When the objective values of the sampled points are changed decreasingly and then increasingly, it is thought that one valley exists. If there exists only one valley, the landscape is unimodal and a greedy strategy like the best strategy is adopted. Otherwise, the rand strategy is adopted. Also, the sampled points realise global search in the region spanned by all search points and realise local search near the best search point. The effect of the proposed method is shown by solving some benchmark problems.

bioinformatics and biomedical applications, Applications of Evolutionary Computation in Biomedical Engineering (IEEE-CEC) attractive method for determining the genetic profile of an individual. Here we focus on a more general and practical issue named short adjacent repeats identification problem (SARIP), which is extended from STR by allowing short gaps between neighbouring units. Presently, the best available solution to SARIP is BASARD, which uses Markov chain Monte Carlo algorithms to determine the posterior estimate. However, the computational complexity and the tendency to get stuck in a local mode lower the efficiency of BASARD and impede its wide application. In this paper, we prove that SARIP is NP-hard, and we also solve it with Chemical Reaction Optimisation (CRO), a recently developed metaheuristic approach. CRO mimics the interactions of molecules in a chemical reaction and it can explore the solution space efficiently to find the optimal or near optimal solution(s). We test the CRO algorithm with both synthetic and real data, and compare its performance in mode searching with BASARD. Simulation results show that CRO enjoys dozens of times, or even a hundred times shorter computational time compared with BASARD. It is also demonstrated that CRO can obtain the global optima most of the time. Moreover, CRO is more stable in different runs, which is

of great importance in practical use. Thus, CRO is by far the best method on SARIP.

Synthesis difficult search problems. However, in multi-objective problem solving, like software architecture generation, the basic variation mechanisms of genetic algorithms (mutation and crossover) tend to lead to mediocre solutions as the evolution favours balancing of several quality properties. In this paper, we explore the acceleration of genetic software architecture generation using a novel approach based on so-called quality farms, i.e., populations which favour a certain quality property. We suggest that by crossbreeding individuals from different quality farms it is possible to create beneficial variance that raises the fitness value to a significantly higher level. Experiments suggest that farm-based crossbreeding improves fitness value about 10percent.

Unimodal Functions designed to find bounds on population-based Evolutionary algorithms solving unimodal functions. We prove its efficiency theoretically and test it on OneMax function. This analysis can be generalised to any similar algorithm using variants of tournament selection and genetic operators that flip or swap only 1 bit in each string.

analysis created by mapping an evolutionary algorithm to the CouchDB object store. The framework decouples the population from the evolutionary algorithm and –through the API CouchDB provides– allows the distributed and asynchronous operation of clients written in different languages. In this paper we present tests which prove that the novel algorithm design still performs as good as a canonical evolutionary algorithm and try to find out what are the main issues concerning it, what kind of speedups should we expect, and how all this affects the fundamental evolutionary algorithms concepts.

framework: investigation into cutting problems optimization., Real-world applications a metaheuristic engine (genetic algorithm), which works as a generator of reduced instances of the original optimization problem, and an integer programming solver. GS has been recently introduced in the literature and achieved promising results in cutting and packing problem instances. In this paper, we present a novel application of crossover operator, the Uniform Order-Based Crossover, to the GS framework. As a means to assess the potentialities behind the novel application, we provide as instantiation of the framework for dealing specifically with the constrained two-dimensional non-guillotine cutting problem. Computational experiments performed over standard benchmark problems are reported and discussed here, evidencing the effectiveness of the novel operator.

Environments (DOPs) whose optima change over time. In this paper, we propose new variants of differential evolution (DE) to solve DOPs. A hybrid method that combines population core based multi-population strategy and prediction strategy and new local search scheme is introduced into DE to enhance its performance for solving DOPs. The population core based multi-population strategy is useful to maintain the diversity of population by using the multi-population and population core concept. The prediction strategy is useful to rapidly adapt to the dynamic environment by using the prediction area. The local search scheme is useful to improve the searching accuracy by suing the new chaotic local search method. Experimental results on the moving peaks benchmark show that the proposed schemes enhance the performance of DE in the dynamic environments.

Agricultural Tasks strategy to handle tasks that are too complex or even too expensive for a single robot. One of these situations is the automation of tasks in the agricultural environment. In this context, one of the main problems consists of determining the best routes (multi-path plan) for the robots to minimise cost, while ensuring a fully completed treatment, i.e., the whole field is covered. The cost can be expressed by a function that considers the most relevant features of each robot in the fleet, for example, in a spray weed treatment, the tank capacity, the number of turns required or the time spent in the whole treatment. This multi-path planning problem can be expressed as a bi-objective problem. In particular, in this paper, two different objectives are taken into account: the cost in time and the cost in money. This formulation allows the analysis of situations in which it is important to distribute the robots to reduce the time of the treatment independently of the money spent and of situations where it is important to reduce the spent money independently of the time consumed. A Non-dominated Sorting Genetic Algorithm II (NSGA-II) is proposed for solving the multi-objective problem. The proposed approach has proved to offer good results in multiple situations dealing with different fields and robots with diverse features. Moreover, the results obtained show that it is possible to determine solutions very close to the optimum of each objective, even simultaneously.

with Immunomodulator (AISI) Intervention computation problems nowadays. The proposed method is developed as an artificial immune system (AIS) which considers the influence of the immunomodulator (AISI), specifically, hormone concentration. The concept of hormone concentration is inducted into current AIS to adjust its decision making based on both large and small scale viewpoints. B-cells and

antibodies are used to deal with small-scale responses because of the characteristics to neutralise high affinity antigens in a certain range. By contrast, the hormone concentration inception is associated with probability matrix has more advantages on large-scale responses. After testing on four databases, the proposed AISI system offered better overall performances to compare with the original AIS and the ant K-means (AK) system.

libraries multi-unit libraries has been a challenging issue all over the world. The materials acquisition for multi-unit libraries can be regarded as a generalised version of the knapsack problem, which was known to be NP-hard, with much more constraints. Thus, it can be computationally expensive to solve the problem. In this paper, the materials acquisition problem in multi-unit libraries is formulated as an integer programming model, and two different constraint-handling mechanisms applied in discrete particle swarm optimization algorithm for obtaining the near optimal solution are presented. It is evident from our computational results that one constraint-handling mechanism can solve the problem effectively and efficiently, while the other one takes more time.

concepts of Genetic Algorithm (GA) and Lbest Particle Swarm Optimisation (Lbest PSO). A new topology, namely 'Dynamically Varying Sub-swarm' has been incorporated in the search process and some selected cross-over and mutation techniques have been used for generation updating. This novel hybridised approach simultaneously ensures a robust search process, a quick convergence and a wide variety of real life applications. Simulations performed over various benchmark functions with the proposed method have been compared with other existing strong algorithms. Experimental results support the claim of proficiency of our algorithm over other existing techniques in terms of robustness, fast convergence and, most importantly its optimal search behaviour.

Genetic Algorithms different biology application domains. When such tools are based on conventional computation techniques, they have shown limitations to approach complex biological problems. In the present study, a genetic algorithm (named GANEL) that is based on some Never-Ending Learning (NEL) principles, is proposed as a tool to extract classification rules from biological datasets. The main goal of the proposed approach is to allow the discovery of concise, yet accurate, high-level rules (from a biological database) which can be used to describe the stronger patterns present in the biological data, revealing concise and relevant information about the application domain, as well as, be used as a classification system. More than focusing only on the classification accuracy, the proposed GANEL approach aims at balancing prediction precision, interpretability and comprehensibility. The obtained results show that the proposed GANEL is promising and capable of extracting useful high-level knowledge that could not be extracted by traditional classifications methods such as Decision Trees, One R and the Single Conjunctive Rule Learner, among others. Moreover, the accuracy of GANEL results (using a small set of attributes per class) are better than Computational Evolutionary Environment (CEE) (previously proposed in the literature) which was designed to the same problem domain.

Selection single objective one. The first point is guide position selection methods for personal best and global best. The second one is the usage of an archive to preserve good positions for Pareto optimal set. In this paper, we consider a guide selection problem in multiobjective particle swarm optimization. A selection method for the personal best that depends on one objective function among plural objective functions is presented. Then, a selection method for the global best that selects among the archived position due to one objective function is presented. The performances of the proposed methods are evaluated by the benchmark problems for the evolutionary multiobjective optimization algorithms.

Cardiac Disease Diagnosis clustering, data analysis and data mining algorithms, termed GA-KM and MPSO-KM, to cluster the dataset of cardiac disease and predict the accuracy of diagnostics. Our proposed GA-KM is a hybrid method that combines a genetic algorithm (GA) and K-means (KM) algorithm, and MPSO-KM is also a hybrid method that combines a momentum-type particle swarm optimization (MPSO) and K-means algorithm. The functions of GA-KM or MPSO-KM are to determine the optimal weights of attributes and cluster centres of clusters that are needed to classify the disease dataset. The dataset, used in this study, includes 13 attributes with 270 instances, which are the data records of cardiac disease. A comparative study is conducted by using C5, Naive Bayes, K-means, GA-KM and MPSO-KM to evaluate the accuracy of presented algorithms. Our experiments indicate that the clustering accuracy of cardiac disease dataset is significantly improved by using GA-KM and MPSO-KM when compared to that of using K-means only.

Problem in Mackay Memorial Hospital Based on Swarm Optimization which has become a hot topic in the fields of manufacturing, logistics, and so on. The purpose of this research is to propose a

methodology for designing the RFID network planning problem (RNP) for application in the Mackay Memorial Hospital in Hsinchu, Taiwan. In this study, the RFID network is first considered as a grid and divided into several small squares. A soft computing methodology called FKB-SSO is proposed to solve the RNP problem based on simplified swarm optimization (SSO) by integrating k-means, fuzzy adaptive resonance theory (fuzzy-ART), and binary search. The proposed FKB-SSO will provide the basis for strategic decisions in constructing the RFID network to reduce the number of RFID readers with a minimal budget under the constraint of 100percent coverage rate. The proposed FKB-SSO is more efficient than PSO and experts' manual solution in both run time and solution quality.

electromagnetic devices simulation-based optimization evolutionary techniques, such as for example Ant Colony Optimisation (ACO), Biogeography Based Optimisation (BBO), Differential Evolution (DE), Population-Based Incremental Learning (PBIL) and Stud Genetic Algorithm (SGA). The design of a microwave filter, a planar array and an elliptical reflect array are here addressed in order to compare their performances on benchmark EM optimization problems. Results show that some techniques (DE, BBO, SGA) are particularly effective in dealing with antenna optimization.

number of function calls Interactive evolutionary computation Pareto-optimal solutions whereof the decision maker can choose the solution that fits best to her or his preferences. In case of limited time (of function evaluations) for optimization this preference information may be used to speed up the search by making the algorithm focus directly on interesting areas of the objective space. The R-NSGA-II algorithm [1] uses reference points to which the search is guided specified according to the preferences of the user. In this paper, we propose an extension to R-NSGA-II that limits the Pareto-fitness to speed up the search for a limited number of function calls. It avoids to automatically select all solutions of the first front of the candidate set into the next population. In this way non-preferred Pareto-optimal solutions are not considered thereby accelerating the search process. With focusing comes the necessity to maintain diversity. In R-NSGA-II this is achieved with the help of a clustering algorithm which keeps the found solutions above a minimum distance epsilon. In this paper, we propose a self-adaptive epsilon approach that autonomously provides the decision maker with a more diverse solution set if the found Pareto-set is situated further away from a reference point. Similarly, the approach also varies the diversity inside of the Pareto-set. This helps the decision maker to get a better overview of the available solutions and supports decisions about how to adapt the reference points.

Diversified Convergence most critical issues in genetic algorithm design. A number of niching techniques have been developed and successfully applied to cope with this problem. For multi-population based parallel genetic algorithms, nevertheless, these approaches are obviously inapplicable, since it is very difficult to obtain global information about entire population during parallel evolution procedure. In the present study, a new island model is proposed to overcome this problem. The new method indiscriminately directs local GAs search with considering the topological information of island model. It only uses local information obtained from a few neighbouring subpopulations to achieve a global population diversification. In the new island model, subpopulations are automatically allocated to different regions of searching space so that they could locate multiple optima including both global optima and local optima, simultaneously orders these found optima according to the connection topology of islands, and keeps them until the end of evolution. In addition, through using the proposed method, the performance of PGA is also improved and displays an enhanced global searching capability. Finally, experimental studies, in both unconstrained optimization and combinatorial optimization, are employed to demonstrate the performance of the new island model.

Project Scheduling Problem Finance, Economics and Management Sciences (IEEE-CEC), Evolutionary Multiobjective Optimisation Constrained Project Scheduling Problem (MRCPSP), in which both the total time of execution and the total cost of assignment are treated as objective functions. An NSGA-II based genetic algorithm is employed for the estimation of the Pareto-optimal solution set. An encoding/decoding scheme guarantees that only feasible individuals are represented in the population, and problem-specific mutation and crossover operators are employed in order to enhance the algorithm efficiency. A case study of the engineering design of the facilities of a new mining plant located in the northern Brazilian territory illustrates the application of the proposed methodology. In this case study, several scenarios of project task assignment to a team of workers with different skills and different hiring costs are generated by the proposed algorithm. This quantitative description of the trade-off between project term and project cost can be particularly useful in the preliminary stage of price negotiation between the engineering consulting firm that develops the project and the client mining company.

optimization. coevolutionary scheme, to solve bi-level optimization problems. It handles population-based algorithms on each level, each one cooperating with the other to provide solutions for the overall problem. Moreover, in order to evaluate the relevance of CoBRA against more classical approaches, a new performance assessment methodology, based on rationality, is introduced. An experimental analysis is conducted on a bi-level distribution planning problem, where multiple manufacturing plants deliver items to depots, and where a distribution company controls several depots and distributes items from depots to retailers. The experimental results reveal significant enhancements, particularly over the lower level, with respect to a more classical approach based on a hierarchical scheme.

data, which brings many troubles to software testing. In order to solve the redundancy of test data, we proposed a novel approach of generating test data by reducing target statements based on dominant relations. First, basic concepts and principles concerning dominance are listed. Then, an approach is proposed to reduce target statements according to their dominant relations. Finally, test suite covering the reduced set of target statements is generated by a genetic algorithm. The generated test suite can also cover all original target statements, which is guaranteed by the proposed strategy. We applied the method to nine benchmark programs, and compared with traditional and greedy methods. The experimental results show that our method can not only reduce redundancy, but also improve the efficiency of generating test data.

Results the assignment of blood can be considered an important real world optimization problem. This paper presents a mathematical model that facilitates good management and assignment of red blood cell units in order to minimise the quantity of imported units from outside the system. The model makes use of the Multiple Knapsack Algorithm, which is implemented using several optimization techniques, in order to determine the most optimal assignments. These include a Genetic Algorithm (GA), Adaptive Genetic Algorithm (AGA), Simulated Annealing Genetic Algorithm (SAGA), Adaptive Simulated Annealing Genetic Algorithm (ASAGA) and finally a Hill Climbing (HC) Algorithm. All techniques were capable of achieving the optimal fitnesses. The AGA, SAGA and ASAGA provide some desirable results over the standard GA, whilst the HC algorithm proves to demonstrate the best results overall.

Evolutionary-Classical Optimization with Engineering Applications evolutionary algorithms using a probabilistic approach coupled to evolutionary search. In this approach the problem is converted into a bi-objective problem, treating the constraint ensemble as a second objective subjected to multi-objective optimization for the formation of a Pareto front, and this is followed by a local search for the optimization of the main objective function. In this process a novel probabilistic modelling is applied to the constraint ensemble, so that the stiff constraints are effectively taken care of, while the model parameter is adaptively determined during the evolutionary search. In this way the convergence to the solution is significantly accelerated and an accurate solution is established. The improvements are demonstrated by means of example problems including comparisons with the standard benchmark problems, the solutions of which are reported in the literature.

End Milling clustering, data analysis and data mining Predicting the surface roughness is an important work for modern manufacturing industry. In this paper, a novel prediction method called Free Pattern Search (FPS) is proposed to explicitly construct the surface roughness prediction model. FPS takes the advantage of the expression tree in gene expression programming (GEP) to encode the solution and to expresses a non-determinative tree using a fixed length individual. FPS is inspired by Pattern Search (PS) and hybrid a scatter manipulator to keep the diversity of the population. Three machining parameters, the spindle speed, feed rate and the depth of cut are used as the independent input variables when prediction the surface roughness in end milling. Experiments are conducted to verify the performance of FPS and FPS obtains good results compared with other algorithm. The predictive model found by FPS agrees with the experimental result. The variable relations are also showed in the predictive model, and the results shows that they are fit to the experiments well.

PSO-based Fuzzy Controller applications important way to improve the traffic efficiency of modern roundabouts. This paper applies a traffic signal controller with two fuzzy layers for signalling roundabouts. The outer layer of the controller computes urgency degrees of all the phase subsets and then activates the most urgent subset. This mechanism helps to instantly respond to the current traffic condition of the roundabout so as to improve real-timeness. The inner layer computes extension time of the current phase and decides whether to turn to the next phase in the running phase subset. As the phase sequences are well-designed, the inner layer smooths the traffic flows which helps to avoid traffic jam. An offline particle swarm optimization (PSO) algorithm is developed to optimise the membership

functions adopted in the proposed controller. In this way, the membership functions in the controller are no longer given by human experience, but provided by the intelligent algorithm. Simulation results demonstrate that the proposed controller outperforms previous traffic signal controllers in terms of improving traffic efficiency of modern roundabouts.

Selection classification problems. This paper proposes two new fitness functions in binary particle swarm optimisation (BPSO) for feature selection to choose a small number of features and achieve high classification accuracy. In the first fitness function, the relative importance of classification performance and the number of features are balanced by using a linearly increasing weight in the evolutionary process. The second is a two-stage fitness function, where classification performance is optimised in the first stage and the number of features is taken into account in the second stage. K-nearest neighbour (KNN) is employed to evaluate the classification performance in the experiments on ten datasets. Experimental results show that by using either of the two proposed fitness functions in the training process, in almost all cases, BPSO can select a smaller number of features and achieve higher classification accuracy on the test sets than using overall classification performance as the fitness function. They outperform two conventional feature selection methods in almost all cases. In most cases, BPSO with the second fitness function can achieve better performance than with the first fitness function in terms of classification accuracy and the number of features.

Many-Objective Optimization Preference handling. multi- objective optimization community. Integrating decision makers' preferences into multi-objective evolutionary algorithm is considered to be an effective approach. This paper presents a new scheme named bipolar preferences dominance for many-objective optimization problems. In the proposed scheme, the solutions are first sorted by the g-dominance to enhance the efficiency of Pareto sorting, and the non-dominated ones are sorted again based on their similarities to increase the proportion of solutions' comparability in high- dimension space. With bipolar preferences dominance, the race is led to the Pareto optimal area which is close to the positive preference and far away from the negative preference. After combining the proposed scheme with NSGA-II methodology, the effectiveness of 2p-NSGA-II was validated on two to fifteen- objective test problems. Moreover, 2p-NSGA-II provides better result when compared with g-dominance based algorithm g-NSGA-II.

Classification optimization a smooth swing can't be achieved without a correct process of body weight transfer between the feet during the motion, which is known as weight shift in golf. As pointed out by various professional players and coaches, a proper weight shift is critical in hitting a shot with good accuracy and range, and therefore it would be beneficial for golfers to obtain weight shift data corresponding to their swing motions, so that analysis and improvement on the swing pose can be made. Weight shift data collected through common methods such as using electronic scales may contain noise data due to factors such as pre-swing movements, and in order for the data to be useful, it is necessary to distinguish actual swing motion from noise. In this paper a data mining approach named Simplified Swarm Optimisation with Sorted Local Search (SSO-SLS), which is based on a variant of Particle Swarm Optimisation (PSO), has been proposed to classify golf swing from weight shift data. In the proposed approach a novel Sorted Local Search strategy has been introduced to remedy the issue of premature convergence facing PSO by allowing particles to obtain information from their nearest neighbours and improve swarm diversity. Experiments on UCI datasets and weight shift data in golf show that SSO-SLS is competitive with common classification techniques, and is an ideal approach for classifying golf swing from weight shift.

Algorithms (IEEE-CEC), Games algorithms (EA) during procedural terrain generation (PTG) processes in video games. A reliable PTG algorithm would allow game maps to be created partially or completely autonomously, reducing the development cost of a game and providing players with more content. Specifically, the use of EA raises possibilities of more control over the terrain generation process, as well as the ability to tailor maps for individual users. In this paper we outline the prominent algorithms that use EA in terrain generation, describing their individual advantages and disadvantages. This is followed by a comparison of the core features of these approaches and an analysis of their appropriateness for generating game terrain. This survey concludes with open challenges for future research.

Discrete and combinatorial optimization. classical job shop scheduling problem (JSP), where each operation is allowed to be processed by any machine from a given set, rather than one specified machine. In this paper, two algorithm modules, namely, hybrid harmony search (HHS) and large neighbourhood search (LNS) are developed for the FJSP with makespan criterion. The HHS is an evolutionary-based

algorithm with the memetic paradigm, while the LNS is typical of constraint-based approaches. To form a stronger search mechanism, an integrated search method is proposed for the FJSP based on the two algorithms, which starts with the HHS, and then the solution is further improved by the LNS. Computational simulations and comparisons demonstrate that, the proposed HHS alone can effectively solve some medium to large FJSP instances, when integrated with the LNS, it shows competitive performance with state-of-the-art algorithms on very hard and large-scale problems, some new upper bounds among the unsolved benchmark instances have even been found.

Selection enduring conundrum in evolutionary biology, which has been studied using a variety of game theoretical models. Most of the previous studies presumed that interactions between individuals are discrete, but behaviour in real systems can hardly be expected to have this dramatically discrete nature. In addition, existing research on continuous strategy games mostly focus on infinite well- mixed populations. Especially, there is few theoretical work on their evolutionary dynamics in structured populations. In the previous work we theoretically studied the game dynamics of continuous strategies in a spatially structured population with its average degree greater than two under weak selection. Here, we study their evolutionary dynamics under weak selection on a cycle (k=2), where each individual only interacts with its two immediate neighbours. Using the concept of fixation probability, we derive exact conditions for natural selection favouring one strategy over another for three update rules, called birth-death, death-birth, and imitation. It shows that for continuous strategy games, the same conditions are derived; especially, the simple rule b/c $>$ k is valid as well, where b/c is the benefit-to-cost ratio of an altruistic act. In addition, we present a network gain decomposition of the game equilibrium, which might provide a new view of network reciprocity, one of five mechanisms for evolution of cooperation.

Genetic Programming Cartesian Genetic Programmin combinational circuits with the aim of reducing the area on a chip as much as possible. In order to optimise complex circuits, Cartesian Genetic Programming (CGP) is employed where the fitness function is based on a formal equivalence checking algorithm rather than evaluating all possible input assignments. The standard selection strategy of CGP is modified to be more explorative and so agile in very rugged fitness landscapes. It was shown on the LGSynth93 benchmark circuits that the modified selection strategy leads to more compact circuits in roughly 50percent cases. The average area improvement is 24percent with respect to the results of conventional synthesis. Delay of optimised circuits was also analysed.

intelligence algorithm and exhibits good performance on optimization. However, during the optimization process, the particles become more and more similar, and gather into the neighbourhood of the best particle in the swarm, which makes the swarm premature convergence probably around the local solution. PSO technique can be augmented with an additional mutation operator that provides diversity and helps prevent premature convergence on local optima. In this paper, diversity concept is evaluated in commonly used PSO algorithms including constriction factor PSO, inertial weight PSO, Gaussian mutation PSO, and a new vibrational mutation PSO combining the idea of mutation strategy related to periodicity. New algorithm is tested and compared with selected PSO algorithms. The results give insight into how mutation operator affects the nature of the diversity and show that the addition of mutation operator with periodicity concept can significantly enhance optimization performance.

analysis analysing a finite-time particle swarm optimization (FPSO) algorithm. Two versions of the FPSO algorithm, which consist of a continuous-time FPSO algorithm and a discrete-time FPSO algorithm, are proposed. Firstly, the continuous-time FPSO algorithm is derived from the continuous model of the particle swarm optimization (PSO) algorithm by introducing a nonlinear damping item that can enable the continuous-time FPSO algorithm to converge within a finite-time interval and a parameter that can enhance the exploration capability of the continuous-time FPSO algorithm. Secondly, the corresponding discrete-time version of the FPSO algorithm is proposed by employing the same discretization scheme as the generalised particle swarm optimization (GPSO) such that the exploiting capability of the discrete-time FPSO algorithm is improved. Thirdly, a Lyapunov approach is used to analyse the finite-time convergence of the continuous-time FPSO algorithm and the stability region of the discrete-time FPSO algorithm is also given. Finally, the performance capabilities of the proposed discrete-time FPSO algorithm are illustrated by using two well-known benchmark functions (global minimum surrounded by multiple minima): Griewank and Rastrigin. In terms of numerical simulation results, the proposed continuous-time FPSO algorithm is used to deal with the problem of odour source localisation by coordinating a group of robots.

Parameter Control computation, Differential evolution parameters, and their performance is highly related to the parameters. A proper set of parameter values is useful for MOEAs in a particular

application. This paper addresses the parameter control problem. Inspired by the observations in differential evolution (DE), we proposed a parameter control system using opposition-based learning (OBL). The proposed method contains three conditions which characterise the state of parameters at different evolutionary stages. It keeps good parameters for the current search stage. In case the parameters are bad, it uses OBL to accelerate the finding of good ones. The method is applied to a newly proposed multiobjective DE algorithm (MODEA) which does not control parameters. The resulting algorithm is tested on CEC 2009 test suite comparing with two other recently proposed MOEAs, namely GDE3 and MOEA/D. Experimental results show that the proposed method can significantly improve the performance of MODEA. Moreover, the resulting algorithm significantly outperforms GDE3 and MOEA/D.

Optimization called the drift particle swarm optimization (DPSO), which is inspired by the free electron model in an external electric field at finite temperature. As the compression-expansion coefficient in DPSO is an important parameter which can greatly influence the performance of the algorithm, three types of control strategies are proposed to control this parameter. The performance of these strategies on the DPSO is comprehensively evaluated on eight benchmark functions. From the experimental results and statistical tests, guidelines about selecting the control method for the compression-expansion coefficient are given.

computation dependencies are hard for linkage learning mechanisms and consequently can be very hard to optimise. The current methods capable of building-block wise crossover begin the search for their models by exploiting dependencies between pairs of variables, thus fail to capture higher-order interactions that can not be easily decomposed into lower ones. This paper introduces an exclusive or (XOR) based higher-order dependency detection algorithm. The method searches for groups of variables where repeatedly applying XOR does not lead to entropy distillation. We experiment with a Genetic Algorithm (GA) that uses a building-block wise crossover according to the linkage model derived with the proposed method. Results show that the GA develops a correct linkage model for allelic-pairwise independent, k-bounded, additively separable test functions, solving them efficiently.

sampling and sequential selection methods. Instead of sampling all the mirrored directions along the principal axes of the covariance matrix, we cluster the eigenvalues of the covariance matrix of a CMA-ES and sample search points on a mirrored eigenspace spanned by eigenvectors that have the same repeated or clustered eigenvalues in the Hessian matrices of the objective functions. We apply this sampling method to a (1,lambda)-CMA-ES and compare its performance with that of a standard $(1,\lambda_{m}^{s})$-CMA-ES that uses the traditional mirroring method. In most of the standard test functions, the new variant is not observed to be marginally worse than the mirrored variant, and it is up to 56percent faster on the sphere function when it is compared with the standard $(1,\lambda)$-CMA-ES.

data mining, Real-world applications many application areas that use patterns generated from their activities has been proposed. Web-based implicit recommender systems are one such application. An implicit recommender system is a tool that helps guide a user to a particular web resource based on implicit data. Implicit data comes from the web users activities without their active participation. Building such a system is a complex process due to two reasons, there is a huge amount of data and the quality of the data is poor. In this research, we tackle the first problem of generating patterns efficiently for recommender system by proposing Hierarchical Particle Swarm Optimisation based clustering (HPSO-clustering). HPSO-clustering is a novel clustering approach based on Particle Swarm Optimisation which combines both the properties of hierarchical and partitional clustering. We grouped the users' session into different clusters. Recommendations for an active user are generated from these clusters. In this paper we report the results of accuracy of recommendations. We achieved an overall 60 to 65percent of precision for an active user, while in some clusters the precision achieved was 100percent when top 5 ranked recommendations were selected.

Smart Phone computation phone by using interactive differential evolution (IDE). From a remarkable progress of the camera sensor in mobile devices, people take the pictures with their mobile phone instead of a digital camera. However, as they are not satisfied with their images in spite of the progress, they still want to edit their images by using mobile applications, which are usually complex and cause user fatigue, especially for beginners. To reduce it and make a simple interface, we exploit IDE which is a kind of interactive evolutionary computation. Let the user IDE to evaluate the individuals. Because of the small parameters of the differential evolution (DE), we could make the tool simply and overcome the user fatigue. DE is also an efficient and fast evolutionary algorithm which uses the difference of

the vectors. Subjective test shows the usefulness of the tool.

Their Applications, Real-world applications vehicles according to a given bus timetable, making vehicle departure times coincide with start times in the timetable, as well as minimising some objectives, such as the number of vehicles used. Vehicle scheduling is very significant for bus companies since an appropriate scheduling solution can reduce operation cost and improve quality of service. In this paper, a cultural clonal selection algorithm based approach is proposed to automatically obtain a vehicle scheduling solution. Firstly a set of candidate blocks is generated using initial start times. Then a cultural clonal selection algorithm is proposed to choose the best subset of blocks from the block set as a scheduling solution. An initial start time based antibody encoding scheme is suggested, which has the advantages of short coding and low complexity of decoding. An objective function is designed to maximise the occurrences of start times in the final solution. An adjusting strategy for departure times of vehicles is designed to improve the final solution. The proposed approach is applied to a real-world vehicle scheduling problem of the Bus Company of Xi'an city in China to evaluate its effectiveness. Experimental results show that the approach can quickly generate reasonable scheduling solutions, which fulfils the practical vehicle scheduling demands.

Prediction in Structural and Energetic Contexts prediction of the native structure of a protein from its amino acid sequence. PSP is a challenging and computationally open problem. Therefore, several researches and methodologies have been developed for it. This paper presents the application of protpred-GROMACS, an evolutionary framework for PSP, in structural and energetic contexts. The performance of mono-objective algorithm was compared with other methodologies, such as multi-objective evolutionary algorithm, coarse grained Monte Carlo and replica exchange molecular dynamics.

Regression Problems Computation, Estimation of distribution algorithms quantum mechanics to improve the performance of classical evolutionary algorithms. This paper describes the latest version of a QIEA model (Quantum-Inspired Linear Genetic Programming, QILGP) to evolve machine code programs. QILGP is inspired on multilevel quantum systems and its operation is based on quantum individuals, which represent a superposition of all programs of search space (solutions). Symbolic regression problems and the current more efficient model to evolve machine code (AIMGP) are used in comparative tests, which aim to evaluate the performance impact of introducing demes (subpopulations) and a limited migration strategy in this version of QILGP. It outperforms AIMGP by obtaining better solutions with fewer parameters and operators. The performance improvement achieved by this latest version of QILGP encourages its ongoing and future enhancements. Thus, this paper concludes that the quantum inspiration paradigm can be a competitive approach to evolve programs more efficiently.

is presented in this study. In MCLPSO, a chaotic local search operator is used and a Simulated Annealing (SA) based local search strategy is developed by combining the cognition-only PSO model with SA. The memetic scheme can enable the stagnant particles which cannot be improved by the comprehensive learning strategy to escape from the local optima and enable some elite particles to give fine-grained local search around the promising regions. The experimental result demonstrates a good performance of MCLPSO in optimising the multimodal functions compared with some other variants of PSO including CLPSO.

Problems attribute clustering was proposed. Hong et al. thus proposed several genetic algorithms for finding appropriate attribute clusters. In this paper, we attempt to improve the performance of the GA-based attribute-clustering process based on the grouping genetic algorithm (GGA). In our approach, the general GGA representation and operators are used to reduce the redundancy of chromosome representation for attribute clustering. At last, experiments are made to compare the efficiency of the proposed approaches and the previous ones.

(IEEE-CEC), Biometrics, bioinformatics and biomedical applications system with nonlinear dynamical behaviour. The rapid response of immune systems to the second time antigen is owing to the stable structure of memory state forming by a closed loop of the idiotypic immune network. A dynamical system of cell population is proposed which explains how the memory state is formed and stabilised in the immune network. stability analysis of antibody dynamics also explains the associativity of immune memory.

prediction clustering, data analysis and data mining optimization (BPSO) method to feature selection problems. Two enhanced versions of binary particle swarm optimization, designed to cope with premature convergence of the BPSO algorithm, are proposed. These methods control the swarm variability using the velocity and the similarity between best swarm solutions. The proposed PSO methods use neural networks, fuzzy models and support vector machines in a wrapper approach, and

are tested in a benchmark database. It was shown that the proposed BPSO approaches require an inferior simulation time, less selected features and increase accuracy. The best BPSO is then compared with genetic algorithms (GA) and applied to a real medical application, a sepsis patient database. The objective is to predict the outcome (survived or deceased) of the sepsis patients. It was shown that the proposed BPSO approaches are similar in terms of model accuracy when compared to GA, while requiring an inferior simulation time and less selected features.

diabetes mellitus mellitus (T1DM) patients, as this can cause unconsciousness or even death. However, it is impossible to monitor the hypoglycemia by measuring patients' blood glucose levels all the time, especially at night. In this paper, a hypoglycemic episode diagnosis system is proposed to determine TIDM patients' blood glucose levels based on these patients' physiological parameters which can be measured online. It can be used not only to diagnose hypoglycemic episodes in T1DM patients, but also to generate a set of rules, which describe the domains of physiological parameters that lead to hypoglycemic episodes. The hypoglycemic episode diagnosis system addresses the limitations of the traditional neural network approaches which cannot generate implicit information. The performance of the proposed hypoglycemic episode diagnosis system is evaluated by using real T1DM patients' data sets collected from the Department of Health, Government of Western Australia, Australia. Results show that satisfactory diagnosis accuracy can be obtained. Also, explicit knowledge can be produced such that the deficiency of traditional neural networks can be overcome. A clear understanding of how they perform diagnosis can be indicated.

Real-Time Strategy (RTS) games using techniques from Evolutionary Computing (EC). The design is novel in its use of a modified Pareto Differential Evolution (PDE) algorithm for bi-objective optimization of the weights of an Artificial Neural Network (ANN) controller when only single-objective optimization has so far been studied. The two main aims of this research are to: (1) develop controllers capable of defeating opponents of varying difficulty levels, which may assist in commercial RTS AI development, and (2) minimise the number of neurons used in the ANN architecture, an issue primarily of efficiency. Experimental results using the popular Warcraft III platform demonstrate success with both aims: the optimised controller was able to win any battle using only a minimal number of hidden neurons, but sub-optimal controllers were able to provide opponents of any intermediate difficulty.

Programming Algorithm PT- NFF-GILP (Phase Transition and New Fitness Function based Genetic Inductive Logic Programming) is proposed in this paper. Based on phase transition of the covering test, PT-NFF-GILP randomly generates initial population in phase transition region instead of the whole space of candidate clauses. Moreover, a new fitness function, which not only considers the number of examples covered by rules, but also considers the ratio of the examples covered by rules to the training examples, is defined in PT-NFF-GILP. The new fitness function measures the quality of first-order rules more precisely, and enhances the search performance of algorithm. Experiments on ten learning problems show that: 1) the new method of generating initial population can effectively reduce iteration number and enhance predictive accuracy of GILP algorithm; 2) the new fitness function measures the quality of first-order rules more precisely and avoids generating over-specific hypothesis; 3) The performance of PT-NFF-GILP is better than other algorithms compared with it, such as G-NET, KFOIL and NFOIL.

multi-meme and hybrid algorithms, Numerical optimization. evolutionary and metaheuristic algorithms. Through CEC 2005 to CEC 2011 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. In this paper we analyse the behaviour of a hybrid algorithm combining two heuristics that have been successfully applied to solving continuous optimization problems in the past. We show that the combination of both algorithms obtains competitive results on the proposed benchmark by automatically selecting the most appropriate heuristic for each function and search phase.

System with Micro Artificial Bee Colony Algorithm Order Controller for a Servo hydraulic positioning system, to compensate the negative effects of fluid leakage across a faulty actuator piston seal. A novel micro artificial bee colony algorithm (mu-ABC) is been proposed in designing this Fractional order Controller based on minimising Integral Time Absolute Error (ITAE) criterion. This mu-ABC requires a less number of bees and hence the solution is obtained much faster than that of basic Artificial Bee Colony (ABC) method. Simulations and comparisons of proposed method in terms of time domain indices indicate the superiority of mu-ABC in designing the fractional controller for a much complex

plant.

for Risk Minimization in Biometric Sensor Network areas. In this paper we deal in designing biometric sensor manager by optimising the risk. Risk is modelled as a multi-objective optimization with Global False Acceptance Rate and Global False Rejection Rate as two objectives. When multiple biometric sensors are used, the decision is taken locally at each sensor and fused using a fusion rule. The optimization involves designing the data fusion rule and setting the sensor thresholds. We propose a new fuzzy dominance based decomposition technique for multi-objective optimization called MOEA/DFD and have compared its performance on other contemporary state-of-arts in multi-objective optimization field like MOEA/D, NSGAII. We have simulated the algorithms on different number of sensor setups consisting of 3, 6, 8 sensors respectively. We have also varied the a priori probability of impostor from 0.1 to 0.9 to verify the performance of the system with varying threat. One of the most significant advantages of using multi-objective optimization is that with a single run just by changing the decision making logic applied to the obtained Pareto front one can find the required threshold and decision strategies for varying threat of imposter. But with single objective optimization one need to run the algorithms each time with change in threat of impostor.

Electric Power Systems topological point of view with respect to a given measurement acquisition system is equivalent to the existence of a certain spanning tree. In previous work, a genetic algorithm was developed in order to address this issue. In this paper the behaviour of this evolutionary algorithm is studied by means of probabilistic methods. Although the main purpose of the algorithm is to find a tree, the determination of the non-existence of the tree due to the uncertainty inherent to evolutionary techniques was addressed using statistical hypothesis testing. This allows to characterise, with a given certainty level, the non-existence of such a solution and, therefore, the non-observability of the EPS. The techniques developed in this paper were tested over two benchmark systems: the IEEE networks with 118 and 300 nodes.

System areas, Real-world applications monitoring systems have been developed. In this paper, we formulate the Bus Sensor Deployment Problem (BSDP) to select the bus routes on which sensors are deployed, and we use Chemical Reaction Optimisation (CRO) to solve BSDP. CRO is a recently proposed metaheuristic designed to solve a wide range of optimization problems. Using the real world data, namely Hong Kong Island bus route data, we perform a series of simulations and the results show that CRO is capable of solving this optimization problem efficiently.

uplink SHO areas. By introducing a penalty-based objective function and some hard constraints, we formally define the problem of balancing SHO areas in UMTS networks. The state-of-the-art mathematical model used and the penalty scores of the objective function are set according to the configuration and layout of a real mobile network, deployed in Slovenia by Telekom Slovenije, d.d.. The balancing problem is then tackled by three optimization algorithms, each of them belonging to a different category of metaheuristics. We report and analyse the optimization results, as well as the performance of each of the optimization algorithms used.

correction codes without a fixed code rate. The property called rateless is attractive to researchers in last decade, and lots of studies have been proposed and attempted to improve the performance of LT codes. One variation is the use of a sparse degree distribution instead of a full one referred to in the encoding process of LT codes to reduce the search space. Observing a fact that the ability of a sparse degree distribution is limited by the nonempty degrees, we introduce a tag selection scheme to choose reasonable sparse degrees for LT codes in this paper. We firstly investigate the influence of different degrees on the error rate of LT codes and then propose a general selection algorithm based on our observations. After that, the covariance matrix adaptation evolution strategy (CMA-ES) is applied to find the optimal sparse degree distributions of which the degrees are defined by our selection algorithm. Finally, the experimental results are presented as evidence to show the proposed scheme is effective and practical.

Algorithm and Networking (IEEE-CEC) Partitioning the set of sensors into several covers over all targets and enabling the covers by turns can effectively extend the lifetime. The problem formulation regarding optimization of sensor partition commonly assumes static networks; however, the composition and topology of real-world WSNs can vary with time due to hardware failure or communication error. This study considers extending the lifetime of dynamic WSNs; specifically, some sensors may fail or recover during the lifetime. In addition, we propose two genetic algorithms (GAs) to deal with this dynamic optimization problem. A series of simulations was conducted to examine the performance of the proposed algorithms. The simulation results validate the effectiveness of the GAs on extending the

lifetime under dynamic network environment.

artificial language with creative properties such as ambiguity and duality of patterning need to be developed. Initially, before using artificial language for creative design, the possibility of transforming between artificial utterances and design concepts should be tested. In this paper, a hybrid system including Holographic Reduced Representations (HRR) and Self-Organising Map (SOM) is built up to represent spatial relations of simple shapes, and develop mapping between the representations and relevant artificial utterances. The computational results have proved that the transformation between artificial language and design concepts can be realised; and the hybrid system could be used as an important part of the brains of curious agents for the evolution of artificial language in computational language games.

Regulatory Network ecology and artificial life (GRN) simulate cell behaviour. More specifically, GRN can determine and regulate cell behaviours using collected external signals through protein sensors. In this paper, we propose to use the GRN properties to control an agent using external perception. More precisely, we will try to evaluate how a GRN can handle and manage simultaneously four conflicting and cooperative continuous actions to solve a new experiment, the Radbot.

(IEEE-CEC) which is where the number of distinct particles collapse. This is a particularly debilitating problem in many practical applications. A new method, the adaptive path particle filter, based on the generation gap concept from evolutionary computation, is proposed for recursive Bayesian estimation of non-linear non-Gaussian dynamical systems. A generation-based path evaluation step is embedded into the general sequential importance resampling algorithm leveraging the descriptive ability of discarded particles. A simulation example of the stochastic volatility problem is presented. In this simulation, the adaptive path particle filter is greatly superior to the standard particle filter and the Markov chain Monte-Carlo particle filter. We present a detailed analysis of the results, and suggest directions for future research.

(IEEE-CEC) two algorithms which are both designed for visualising data. One algorithm consists of a neuroscale algorithm which uses different Bregman divergences. The other uses a similar algorithm but based on reservoir computing. We show that the latter is much better because it captures the dynamical nature of the financial time series and thus reveals more explicit information. By investigating a slightly different cost function, we show that the latter mapping is not creating information which does not exist in the original time series.

Neutral Portfolios (IEEE-CEC) positions that ensures a risk less portfolio in terms of its exposure to the relevant market benchmark. While a naive formulation of the EMNP optimization problem can be easily solved using linear programming techniques, the inclusion of the Risk Budget constraint on the high risk assets, together with the other EMNP specific constraints of zero net market exposure, close-to-zero portfolio beta and zero financial leveraging, besides the bounding constraints imposed on the long-short positions and high risk assets, can turn the problem difficult for direct solving using traditional methods. This work aims to solve such a complex constrained EMNP optimization problem using a meta-heuristic method viz., Differential Evolution (rand/1/bin) with Hall of Fame (DE HOF). The DE HOF exploits a penalty function strategy and employs weight standardisation procedures to ensure faster convergence and an efficient tackling of complex constraints to yield optimal portfolios within realistic time. Experimental studies which include a rigorous out of sample performance analysis have been undertaken on the Bombay Stock Exchange data set (BSE 200: March 1999-March 2009) which included both upturns and downturns in the global markets.

Price and Geodesic Distance (IEEE-CEC) and their geodesic distance from the departure airport to the destination. Using the data collected from a Japanese flight booking site, I empirically investigated demand-supply situations from parameter estimates of an nth order polynomial function of the price in terms of the distance on each observation date. An adequate order of the polynomial function is determined by using two kinds of information criteria (AIC and BIC). It is confirmed that the ticket availability strongly depends on the Japanese calendar date and that the parameter estimates also depend on the calendar date. The parameter estimates may correspond to demand-supply situations of the Japanese air travel market.

Price Trend Analysis Finance, Economics and Management Sciences (IEEE-CEC) of financial data have had success in using predictability pretests to determine whether the time series under analysis by a GP contains patterns that are actually inherently predictable. However, most studies to date apply no such pretests, or pretests of any kind. Most previous work in this area has attempted to use filters to ensure inherent predictability of the data within a window of a time series, whereas other

works have used multiple time frame windows under analysis by the GP to provide one overall GP recommendation. This work, for the first time, analyses the use of external information about the price trend of a stock's market sector. This information is used in a filter to bolster confidence of a GP-based alert regarding formation of a trend for the chosen stock. Our results indicate a significant improvement in trend identification for the majority of stocks analysed using intraday data.

(IEEE-CEC) and optimise a portfolio of assets. However, traditional optimization software does not provide for value-at-risk optimization. One solution is to apply evolutionary techniques to search for optimal solutions. However, to increase the realism in evolutionary solutions, it is important to consider the inclusion of realistic real-world constraints and to further consider the effect of the initialisation scheme on the results achievable. Two techniques are investigated in this work. The key technique is multi-objective differential evolution (MODE) which is applied together with an adapted initialisation scheme to search for VaR-optimal portfolios in the presence of real-world constraints. Further, NSGA-II, a more established multi-objective optimization technique; is implemented and extended with real world constraints and a refined initialisation scheme, so as to compare the benefits of the MODE technique in the light of a refined NSGA-II technique and highlight the benefits of such refinements on NSGA-II itself.

Algorithms with Local Search Management Sciences (IEEE-CEC), Multiobjective optimization problem with money as the resource to be allocated to assets. We first have to select the assets from a pool of them available in the market and then weight them appropriately to maximise the return and minimise the risk associated with the Portfolio. In our work, we have introduced a new greedy coordinate ascent mutation operator and we have also included the trading volumes concept. We have performed simulations with the past data of NASDAQ100 and Dow-Jones30, concentrating mainly on the 2008 recession period. We also compare our results with the indices and the simple Genetic Algorithms approach.

Finance, Economics and Management Sciences (IEEE-CEC), Finance and economics effectiveness of price limits. We consider three different learning styles: zero-intelligence (ZI), zero-intelligence-plus (ZIP), and genetic programming learning. Our results indicate that the different learning behaviour indeed gives rise to different impacts on the market. Therefore, policy makers have to take into account traders' learning styles when they plan to impose financial regulations on the market so as to achieve the effects they expected.

(IEEE-CEC), Finance and economics, Real-world applications property rights (IPR) in economic and other literature our understanding of the impact of these rights on the process of technological advance is surprisingly incomplete. In this paper we focus on one form of IPR, namely patents. An important and open question faced by policy-makers is what form of patent regime will encourage the fastest rate of technological progress in a society. It is difficult to address this question using historical empirical data as the legal, cultural and technological environments (to name but a few of the factors which could impact on the effect of a given patent regime) do not remain constant over time. Consequently, in this study we employ an agent-based methodology in order to isolate and examine the rate of technological advance that different patent regimes produce. The simulation results indicate that perhaps counter intuitively, patent policy may not in fact be an effective means of driving societal technological advance.

Numerical Optimization inspired by biogeography. BBO has demonstrated good performance on various benchmark functions and real-world optimization problems. However, the performance of BBO is sensitive to the migration model which provides the most important control parameters, immigration rate and emigration rate. According to no free lunch theorem, it is impossible for BBO with a single migration model to obtain always good performance. In this paper, BBO with an ensemble of migration models (BBO-EMM) is introduced and is realised using in three parallel populations. The performance is tested on a set of 25 benchmark functions of CEC 2005 and compared with variant versions of BBO with a single migration model with respect to optimization ability and running time. Results show that the proposed BBO-EMM is better than other BBO algorithms for the problems that we studied in this paper.

a Real-World Optimization Problem important research topic in the evolutionary computation field. The Economic Load Dispatch is one of the well-known complex practical problems. The problem is usually represented by a nonconvex constrained optimization model. In this paper, we propose to use an ensemble of three different Constraint Consensus (CC) methods within the Differential Evolution algorithm to solve the Economic Load Dispatch problem. During the evolution process, an adaptive

mechanism is used to assign the infeasible solutions to each CC method with the emphasis on the best performing one. The experimental results show that the proposed algorithm is not only able to reach the 100percent feasibility ratio, but that it is also able to obtain better solutions in comparison to the state-of-the-art algorithms

essential to find good solutions in limited computational time for many practical systems. This paper first presents a constructive heuristic, namely improved standard deviation heuristic (ISDH), by combining the standard deviation heuristic (SDH) with the procedure of effective double-job-insert-operator. Then, a composite heuristic, improved standard deviation heuristic with iteration (ISDHI), is proposed using the iteration operator to improve the solutions of the ISDH. Extensive computational experiments are carried out based on a set of well-known flow shop benchmark instances that are considered as no-wait flow shop scheduling instances. Computational results and comparisons show that the ISDHI perform significantly better than the existing ones, and the ISDHI heuristic further improve the proposed constructive heuristics for no-wait flow shop scheduling problem with total flow time criterion.

helicopter loads Intelligence (IEEE-CEC), Defence and cyber security, Classification, clustering, data analysis and data mining life cycle management and life extension efforts. This paper explores continued efforts to use evolutionary computation (EC) methods and machine learning techniques to estimate several helicopter dynamic loads. Estimates for the main rotor normal bending (MRNBX) on the Australian Black Hawk helicopter were generated from an input set that included thirty standard flight state and control system parameters under several flight conditions (full speed forward level flight, rolling left pullout at 1.5g, and steady 45deg left turn at full speed). Multiobjective genetic algorithms (MOGA) used in combination with the Gamma test found reduced subsets of predictor variables with Madelin potential. These subsets were used to estimate MRNBX using Cartesian genetic programming and neural network models trained by deterministic and evolutionary computation techniques, including particle swarm optimization (PSO), differential evolution (DE), and MOGA. PSO and DE were used alone or in combination with deterministic methods. Different error measures were explored including a fuzzy-based asymmetric error function. EC techniques played an important role in both the exploratory and Madelin phase of the investigation. The results of this work show that the addition of EC techniques in the modelling stage generated more accurate and correlated models than could be obtained using only deterministic optimization.

Constrained Optimization have been proposed with excellent performance on mathematical benchmarks. However, like any other optimization algorithm, the success of DE is highly dependent on its search operators and control parameters. Although a considerable number of investigations have been carried out for parameter selection, it is seen as a tedious task. In this paper, we propose a DE algorithm that uses an adaptive mechanism to select the best performing combination of parameters (amplification factor, crossover rate and the population size) during the course of a single run. The performance of the algorithm is compared on a set of 24 constrained optimization test problems. The results demonstrate that the proposed algorithm not only saves the computational time, but also shows better performance over the state-of-the-art algorithms.

Learning Process Economics and Management Sciences (IEEE-CEC) affect market in the long term or not. Theoretical model can only explain part of these empirical studies. In this paper, we incorporate information diffusion model into an agent-based artificial market and test if the difference of investment experience leads the long time impact of false information. Our result provides an explanation to empirical studies that if connected agents are rich in investment experiences, they can distinguish false information under the condition of heterogeneous information sources. Consequently, informed agents have a low probability to release false information in the long term.

and Social Networks (IEEE-CEC), Coevolution and collective behaviour prototypical model of a system in which agents, competing for scarce resources, inductively adapt their belief-models to the aggregate environment that they jointly create. The works on the El Farol Bar problem which retained the best-reply learning of that seminal model show that, if the agents make use of global information, the aggregate attendance keeps fluctuating around the threshold level. Works where best reply behaviour has been replaced with reinforcement learning show that the system converges to an equilibrium characterised by a group of agents who always go to the bar and a group of agents who always stay at home. In this paper, we first introduce social networks: in our model, the agents take their decisions on the basis of their neighbours' past decisions. We investigate the effect of two network structures: the circular neighbourhood and the von Neumann neighbourhood. Simulations

show, first, that the system always reaches a state of perfect coordination and, secondly, that many kinds of equilibria emerge, each of which is characterised by a certain number of classes in terms of attendance frequency. We then modify this network-based model by introducing minimum attendance thresholds. Simulations show that even with very low minimum attendance thresholds the equilibrium characterised by perfect equality is the most likely outcome. In particular, we show that it takes just one fourth of the agents with 'Keep-up-with-the Joneses' behaviour to always lead the system to the perfect equality equilibrium.

(IEEE-CEC) management system capable of supporting higher usage of renewable energy sources is being developed. The system receives flexible offers from producers and consumers of energy, aggregates them on a regional level and schedules the aggregated flexible offers to balance forecast energy supply and demand. This paper focuses on formulating and solving the optimization problem of scheduling aggregated flexible offers within such a system. Three metaheuristic scheduling algorithms (a randomised greedy search, an evolutionary algorithm and a hybrid between the two) tailored to this problem are introduced and their performance is assessed on a benchmark test problem and two realistic problems. The best results are achieved by the evolutionary algorithms, which can efficiently handle thousands of aggregated flex-offers.

Smart Grid Applications (IEEE-CEC) structure, since it has the function of detecting the necessity of performing global control actions in real time. Due to the short-time requirements of real time applications, the eligible vulnerability assessment methods have to consider the improvement of calculation time. Although there are several methods capable of performing quick assessment, these techniques are not fast enough to analyse real large power systems in real time. Based on the fact that vulnerability begins to develop in specific regions of the system exhibiting coherent dynamics, large interconnected power systems can be reduced through dynamic equivalence in order to reduce the calculation time. A dynamic equivalent should provide simplicity and accuracy sufficient for system dynamic simulation studies. Since the parameters of the dynamic equivalent cannot be easily derived from the mathematical models of generators and their control systems, numerical identification methods are needed. Such an identification task can be tackled as an optimization problem. This paper introduces a novel heuristic optimization algorithm, namely, the Mean-Variance Mapping Optimisation (MVMO), which provides excellent performance in terms of convergence behaviour and accuracy of the identified parameters. The identification procedure and the level of accuracy that can be reached are demonstrated using the Ecuadorian-Colombian interconnected system in order to obtain a dynamic equivalent representing the Colombian grid.

mutated operation (FPSOCM), where a fuzzy logic is applied to determine the inertia weight of PSO and the control parameter of the proposed cross-mutated operation based on human knowledge. By introducing the fuzzy system, the value of the inertia weight of PSO becomes adaptive. The new cross-mutated operation effectively drives the solution to escape from local optima. To illustrate the performance of the FPSOCM, a suite of benchmark test functions are employed. Experimental results show the proposed FPSOCM method performs better than some existing hybrid PSO methods in terms of solution quality and solution reliability (standard deviation upon many trials). Moreover, an industrial application of economic load dispatch is given to show that the FPSOCM method performs statistically more significant than the existing hybrid PSO methods.

forecasting using orthogonal design with reasonable accuracy. Past traffic flow data, which has been captured by on-road sensors, is used as the inputs of neural networks. The size of this data significantly affects the performance of short-term traffic flow forecasting, as too many inputs result in over-specification of neural networks and too few inputs result in under-learning of neural networks. However, the amount of past traffic flow data input, is usually determined by the trial and error method. In this paper, an experimental design method, namely orthogonal design, is used to determine appropriate amount of past traffic flow data for neural networks for short-term traffic flow forecasting. The effectiveness of the orthogonal design is demonstrated by developing neural networks for short-term traffic flow forecasting based on past traffic flow data captured by on-road sensors located on a freeway in Western Australia.

to Play against Itself IPD (Iterated Prisoner's Dilemma) game under various conditions. In some studies, each agent is allowed to play against itself. However, this setting is somewhat strange because we do not play any real-world games against ourselves. In this paper, we examine the effect of this somewhat strange setting on the evolution of cooperative behaviour in a spatial IPD game. Two cases are compared with each other: Each agent is allowed to play against itself in one case and not allowed

to do so in the other case. It is shown through computational experiments that similar results are obtained from these two cases when opponents of each agent are selected from a large number of its neighbours. However, the difference between the two cases is large when the number of neighbours is small. Actually the evolution of cooperative behaviour is strongly facilitated by allowing each agent to play against itself when the number of neighbours is small. Our computational experiments are performed on a spatial IPD game with various specifications of the neighbourhood size where binary and real number strings are used as game strategies.

evaluate their algorithms on a variety of real-time video games with different degrees of complexity. These competitions, which vary from classical arcade games like Ms Pac-Man to racing simulations (Torcs) and real-time strategy games (StarCraft), are essential to establish a uniform testbed that allows practitioners to refine their algorithms over time. In this paper we propose a new competition to be held at WCCI 2012: the Physical Travelling Salesman Problem is an open-ended single-player real-time game that removes some of the complexities evident in other video games while preserving some of the most fundamental challenges. This paper motivates and outlines the PTSP and discusses in detail the framework of the competition, including the software interfaces, parameter settings, rules and details of submission.

Been Made? There are numerous examples ranging from bacteria through humans showing fitness can sometimes improve if individuals cooperate. Yet despite the widespread evidence of cooperation throughout nature, we still do not fully understand how it evolves. Over the past 10-15 years a large number of theoretical (computer) models have been created, analysed and published to try and get some answers. Unfortunately, little progress has been made despite all of this time and effort. In this paper we review what has been done and explain why the current directions of research in modelling cooperation in populations is unlikely to provide any insight. We make recommendations on the proper path for future research efforts.

Representation Schemes Prisoner's Dilemma) game, which are encoded using different representation schemes. Each agent at a cell in a two-dimensional grid-world has its own representation scheme for encoding its game strategy. Strategies with different representation schemes cannot be recombined. Thus a population of agents can be viewed as a mixture of different species (i.e., an ecology with different species). When the size of a neighbourhood structure is small and/or the number of representation schemes is large, it is very likely that some agents have no neighbours with the same representation scheme. We discuss the handling of those agents because they cannot generate their new strategies through recombination. In computational experiments, we use four types of strings (i.e., binary strings of length 3, real number strings of length 3, binary strings of length 7, and real number strings of length 7). Agents in our spatial IPD game are randomly divided into four groups of the same size. One string type is assigned to each group. Recombination is performed between neigh boring agents with the same string type. With respect to the IPD game, we compare the following two settings with each other. In one setting, the IPD game is played between any pair of neigh boring agents regardless of their string types. In the other setting, it is played only between neighbouring agents with the same string type. Using these two settings, we examine the effect of the IPD game between agents with different representation schemes on the evolution of IPD game strategies. We also examine the effect of the number of different representation schemes in a population.

for the generation of interesting and balanced game rules. Dominion is a trading-card-like game where each card type represents a different game mechanic. Each play through only features ten different cards, the selection of which can form a new game each time. We compare and analyse three different agents that are capable of playing Dominion on different skill levels and use three different fitness functions to generate balanced card sets. Results reveal that there are particular cards of the game that lead to balanced games independently of player skill and behaviour. The approach taken could be used to balance other games with decomposable game mechanics.

Game (IEEE-CEC), Games strategy selection in simultaneous multistage games. We evaluate the algorithm using a battle planning scenario in which replanning is possible. We show that the algorithm can be used to select a strategy that approximates a Nash equilibrium strategy, taking into account the possibility of switching strategies part way through the execution of the scenario in the light of new information on the progress of the battle.

World Network Search Space (IEEE-CEC), CIGPU-2012 large network space consisting of fisheries management data. The parallel search solution is capable of determining global maxima of the search space using exhaustive search, compared to local optima located by machine learning solutions such

as evolutionary computation. The actual solutions from the best machine learning technique, called Probabilistic Adaptive Mapping Developmental Genetic Algorithm, are compared by a fisheries expert to the global maxima solutions returned by parallel search. The time required for parallel search, for both CPU and GPU-based solutions, are compared to those required for machine learning solutions. The GPU parallel computing solution was found to have a speedup of 12x over a multi-threaded CPU solution. An expert found that overall the machine learning solutions produced more interesting results by locating local optima than global optima determined by parallel processing.

with CUDA (IEEE-CEC), CIGPU-2012 Algorithm (NHBSA) on GPUs with CUDA and apply the algorithm to solve large scale QAP instances. To solve large scale QAP instances, we combined the taboo search with NHBSA. In this implementation, we used an efficient thread assignment method, Move-Cost Adjusted Thread Assignment (MATA), which is proposed in a previous study. Through these experiments, we show that MATA plays an important role for efficient parallel computation in NHBSA. We also show the effectiveness of running NHBSA on multiple GPUs using the island model in independent run mode.

a Chess Evaluation Function Intelligence and Games (IEEE-CEC) a chess engine based on evolutionary programming with a selection mechanism that relied on grandmaster's chess games. The objective was to decide the virtual players that would pass to the following generation. Here, we use these same techniques to adjust a larger number of weights (29 in this work instead of the 5 used in the previous one). The aim was to improve the rating of our chess engine. We also introduce here the use of a local search scheme based on the Hooke-Jeeves algorithm, which is adopted to adjust the weights of the best virtual player obtained in the evolutionary process. As our results indicate, this produced a further improvement in the rating of our chess engine. As in our previous work, the material values of the additional pieces considered here are similar to the values known from chess theory.

sequence represents an important and challenging problem in computational biology. In this paper, we propose a novel heuristic approach for protein structure prediction (PSP) based on the concept of optimal hydrophobic core formation. Using 2D HP model, a well-known set of substructures analogous to the secondary structures are obtained. Some sub-conformations are appropriately classified and then incorporated as prior knowledge. Unlike most of the popular PSP approaches which are stochastic in nature, the proposed method is deterministic. The effectiveness of the proposed algorithm is evaluated by well-known benchmark as well as non-benchmark sequences commonly used with 2D HP model. Maintaining similar accuracy as other core based and population based algorithms our method is significantly faster and reduces the computation time as it avoids blind search within the hydrophobic core (H-Core).

Swarm Intelligence better understanding of mechanisms at the molecular level that govern essential processes inside the cell. The interaction mechanisms are conventionally modelled by nonlinear dynamic systems of coupled differential equations (S-systems) adhering to the power-law formalism. Our implementation adopts an S-system that is rich enough in structure to capture the dynamics of the gene regulatory networks (GRN) of interest. A comparison of three widely used population-based techniques, namely evolutionary algorithms (EAs), local best particle swarm optimization (PSO) with random topology, and artificial bee colony (ABC) are performed in this study to rapidly identify a solution to inverse problem of GRN reconstruction for understanding the dynamics of the underlying system. A simple yet effective modification of the ABC algorithm, shortly ABC* is proposed as well and tested on the GRN problem. Simulation results on two small-size and a medium size hypothetical gene regulatory networks confirms that the proposed ABC* is superior to all other search schemes studied here.

Analysis of Aryl Beta-Diketo Acids for HIV-1 Integrase Inhibition algorithm is proposed as a feature selection algorithm in the development of quantitative structure-activity relationship (QSAR) models. DE is used to evolve the velocities of the particle swarm from which a series of rules are used to determine the discrete values of the position vectors which form chemical descriptor subsets. These descriptor subsets are then used to develop models for QSAR analysis. DE-BPSO was found to outperform the standalone BPSO algorithm. The DE-BPSO algorithm was then used to develop multiple linear regression models for the analysis of aryl beta-diketo acid compounds for the inhibition of HIV-1 integrase. This model highlights the significance of hydrophobicity and partial positive charges of the hydrogen atoms on the molecular surface in influencing the biological activities of these compounds for the inhibition of HIV-1 integrase.

cellular dynamics for thousands of genes simultaneously, thereby enabling reverse engineering of the gene regulatory network (GRN) from high-throughput time-series gene expression data. Amongst the

various currently available models for inferring GRN, the S-System formalism is often considered as an excellent compromise between accuracy and mathematical tractability. In this paper, a novel approach for inferring GRN based on the decoupled S-System model, incorporating the new concept of adaptive regulatory genes cardinality, is proposed. Parameter learning for the S-System is carried out in an evolving manner using a versatile and robust Trigonometric Evolutionary Algorithm. The applicability and efficiency of the proposed method is studied using a well-known and widely studied synthetic network with various levels of noise, and excellent performance observed. Further, investigations of a 5 gene in-vivo synthetic biological network of Saccharomyces cerevisiae called IRMA, has succeeded in detecting higher number of correct regulations compared to other approaches reported earlier.

bioinformatics and biomedical applications major effort of evolutionary biology. Such inference can be accomplished through the use of individual genes, sets of genes, or complete genomes. While the latter may provide the most robust description of the true phylogenetic history, the computational demands of complete genome comparison and phylogenetic construction is daunting. Thus most researchers are left using sets of conserved genes for the resolution of a common phylogeny (what is termed a supertree search). However as the number of taxa increases, the number of possible supertree solutions increases tremendously. This requires consideration of methods to search this space efficiently. Here for the first time we present a method for supertree search using evolutionary algorithms and evaluate its utility on a set of derived supertree problems with 50 taxa. The results indicate the utility of this approach and offer opportunities for future refinement.

Represented in Only a Subset of Sequences of Interest bioinformatics and biomedical applications Motif Inference), which allows the system to ignore some of the sequences when looking for candidate conserved motifs in noncoding DNA. This ability is useful both when looking for candidate motifs in co-expressed genes (where it is not expected that all genes respond to the same transcription factors) and when looking for candidate motifs in divergent species (where functional elements might appear only in related species). In these cases, we would like to allow the inferred motif to be present in only a subset of the input data. This paper provides background information about the problem, describes our approach, and presents results. By excluding some sequences from the match process, GAMID succeeds at finding known functional elements.

Inference bioinformatics and biomedical applications modules that employs an evolutionary search to identify modules conserved across a set of DNA sequences from different species. This paper describes the motivation and system design for GAMMI, and presents the results of initial tests of the system using artificial sequences with implanted artificial modules. Based on these preliminary tests, GAMMI appears to be a promising approach to the module inference problem.

Engineering on Gene Regulatory Networks distribution algorithms, Numerical optimization. interactions between different genes. One of the most important tasks in biology is to find the right regulations in a network given observed data. The problem, is that the observed data is often noisy, and we have to use models robust to noise and scalable to hundreds of genes. Recently, Recurrent Neural Networks has been presented as a viable model for GRNs, which is robust to noise and can be scaled to larger networks. In this paper, to optimise the parameters of the RNN, we implement a classic Population Based Incremental Learning (PBIL), which in certain scenarios has outperformed classic GA and other evolutionary techniques like PSO. We test this implementation on a small and a large artificial networks. We further study the optimal parameters and discuss the advantages of the method.

Evolutionary Fleet Scheduling Surveillance and Defence (IEEE-CEC) which tasks they can or cannot do given a specified fleet of heterogeneous platforms (such as vehicles or aircraft). We introduce the Stochastic Fleet Estimation under Steady State Tasking (SaFESST) model to determine which tasks will not be achievable. SaFESST is a bin-packing model which uses a fleet configuration (the assignment of specific platforms to each of the tasks) to fit each task from a scenario within the platform bins (the height of the bin represents the number of platforms). Each individual platform is represented by a strip of scenario length which is packed by sub-tasks it can carry out. SaFESST is run on a set of 10,000 scenarios for a single fleet configuration. Results are reported on various statistics of tasks that are unachievable.

Surveillance and Defence (IEEE-CEC) search-and-rescue (SAR) incident has long been a focus of many governments and organisations. Finding innovative solutions that guarantee a swift reaction to the distressed entity with a rational use of the available resources is pivotal to the success of the SAR operation. In spite of the plethora of successfully deployed SAR systems, we witness a substantial gap when it comes to the integration of risk-driven analyses into the underlying machinery of any decision

support platform that leans upon the in-field SAR assets. This paper extends a recently proposed risk management framework [1] by adding automated modules for risk monitoring and response selection. An evolutionary multi-objective optimization algorithm is used to navigate across the discrete space of all available assets and their set of actions in order to present a limited number of promising responses to a SAR operator, who will ultimately decide what action must be carried out. The proposed methodology was validated in the context of a simulated nautical SAR scenario in the Canadian Atlantic coastline with nine different types of ground, maritime and aerial assets.

Edge Detection in Noisy Images continuous edges in noisy images is a hard problem. The Canonical Particle Swarm Optimisation (CanPSO) has been used for edge detection since 2009. Although the Bare Bones PSO (BBPSO) and the Fully Informed Particle Swarm (FIPS), as two well-known versions of PSO, have interesting features to overcome noise, they have never been applied to edge detection in noisy images. In this paper, six different static topologies along with two dynamic topologies are implemented within the three versions of PSO and their effects are investigated in a PSO-based edge detector in noisy images. Computational experiments show that FIPS with the toroidal topology outperforms the canonical and bare bones PSO with various static and dynamic topologies in most cases and is more robust to noise.

Malt Classification feature extraction programs are competitive with human derived programs for a difficult real world texture classification problem. The problem involves distinguishing images of three classes of bulk malt. There are subtle differences between the three classes. We have used a number of human derived methods, Haralick, Gabor, Haar, histogram and Galloway, to get feature vectors for the malt problem. We have also used a number of feature extraction programs that were evolved from thirteen Brodatz textures. We performed classification with a 1 nearest neighbour classifier. The evolved features gave an accuracy of 67percent which is considerably better than the 53percent achieved with the Haar features, but not as good as the 77percent achieved with the Galloway features. Analysis of the evolved features suggested that they are capturing some texture regularities not captured by the human derived methods. We conclude that the evolved features are competitive with the human derived features and can provide enhanced accuracy when used in conjunction with human derived features.

Evolutionary Computer Vision, Evolutionary programming previous work that analyses the outputs from a GP detector before thresholding them to binary edge maps. When the threshold used in a GP system slightly changes, the final edge map from a detector may change a lot. Mapping the outputs of a GP detector to a grayscale space by a linear transformation is not effective. In order to address the problem of the sensitivity to the threshold values, we replace the linear transformation with an S-shaped transformation. We design two new fitness functions so that the outputs from an evolved detector can obtain better edge maps after mapping into a grayscale space. Experimental results show that the S-shaped transformation obtains soft edge maps similar to the fixed threshold and the new fitness functions improve the edge detection accuracy.

Optimization visualisations and simulations. They are obtained by laser scanners, computer vision systems or medical imaging devices to model highly detailed object surfaces. Surface mesh simplification aims to reduce the number of faces used in a 3D model while keeping the overall shape, boundaries, and volume. In this work, we propose to deal with the mesh simplification problem from an evolutionary multi-objective viewpoint. The quality of a solution is defined by two conflicting objectives: the accuracy and the simplicity of the model. The Non-dominated Sorting Genetic Algorithm II (NSGA-II) is adapted to tackle the problem. We compare the NSGA-II performance with a classical approach and a single-objective implementation. The comparison has been carried out using different datasets.

Algorithms cooperative co-evolutionary multi-objective evolutionary algorithms (CCMOEAs). The CCMOEAs chosen are based on the following state-of-the-art multi-objective evolutionary algorithms (MOEAs): Non-dominated Sorting Genetic Algorithm II (NSGA-II), Strength Pareto Evolutionary Algorithm 2 (SPEA2) and Multi-objective Cellular Genetic Algorithm (MOCell). The cooperative co-evolutionary variants presented in this article differ from the standard MOEAs architecture in that the population is split into islands, each of them optimising only a sub-vector of the global solution vector, using the original multi-objective algorithm. Each island evaluates complete solutions through cooperation, i.e., using a subset of the other islands current partial solutions. We propose to study the performance of the asynchronous CCMOEAs with respect to their synchronous versions and base MOEAs on well known test problems, i.e. ZDT and DTLZ. The obtained results are analysed in terms of both the quality of the Pareto front approximations and computational speedups achieved on a

multicore machine.

variants have been introduced. However, no single variant consistently performed well over a range of test problems with different mathematical properties. In this paper, a memetic multi-topology particle swarm optimiser (MMTPSO) is introduced for solving constrained optimization problems. MMTPSO uses the strengths of two different particle swarm topologies and during the evolution process the algorithm is designed to emphasise the best performing topology. Moreover, to increase the convergence pattern of the proposed algorithm, a local search algorithm is periodically used. MMTPSO shows a superior performance to its independent variants, as well as other state-of-the-art algorithms, by solving 13 well known test problems

Differential Evolution can convert algorithms for unconstrained problems to algorithms for constrained problems using the epsilon level comparison, which compares search points based on the pair of objective value and constraint violation of them. We have proposed the epsilon constrained differential evolution eDE, which is the combination of the epsilon constrained method and differential evolution (DE), and have shown that the eDE can run very fast and can find very high quality solutions. In this study, we propose the epsilon constrained rank-based DE (eRDE), which adopts a new and simple scheme of controlling algorithm parameters in DE. In the scheme, different parameter values are selected for each individual. Small scaling factor and large crossover rate are selected for good individuals to improve the efficiency of search. Large scaling factor and small crossover rate are selected for bad individuals to improve the stability of search. The goodness is given by the ranking information. The eRDE is a very efficient constrained optimization algorithm that can find high-quality solutions in very small number of function evaluations. It is shown that the eRDE can find near optimal solutions stably in about half the number of function evaluations compared with various other methods on well known nonlinear constrained problems.

optimisation constrained Multi-objective (MO) optimisation problems so far. Recently, we proposed a Most Probable Point (MPP) based repair method for equality constraint handling, where we concentrated on single-objective optimization problems. In the present work, we focus our attention to equality constrained MO optimization. We first propose a set of equality constrained MO test problems (having up to 30 variables) and then suggest a more pragmatic clustering based method for selecting the infeasible solutions to be repaired which reduces the number of function evaluations considerably. The repair procedure is integrated with the popular Evolutionary MO optimization (EMO) procedure, the NSGA-II. The results will show that the proposed procedure reaches the feasible state faster, as compared to NSGA-II for all the test problems and hence show promise as an effective method for handling equality constraints in MO optimization.

Knapsack Problem problem is presented. In this approach the potential solutions are represented by vectors of real values; the dimension of each vector corresponds to the number of constraints of the problem rather than the number of items. Each of these values measures the significance of the corresponding constraint and, together with the value of each item, is used to define a ratio of goodness for each item. The particle swarm optimization algorithm is used to find the best profit by sorting all items according to the ratio of their goodness and by picking these items in the sorted order. Also, a special initialisation phase and an improvement phase are incorporated into the algorithm. The proposed approach was tested on several standard test benchmarks and its results are compared with some other heuristic methods in terms of solution quality and the CPU time. These comparisons show that the proposed method is able to find quality solutions faster than most of other methods. Also, our experiments show that the algorithm is more efficient for the problems in which the number of constraints is smaller than the number of items.

studied and successfully applied. While a better understanding of PSO and particle behaviours have been obtained through theoretical and empirical analysis, some issues about the behaviour of particles remain unanswered. One such issue is how velocities should be initialised. Though zero initial velocities have been advocated, a popular initialisation strategy is to set initial weights to random values within the domain of the optimization problem. This article first illustrates that particles tend to leave the boundaries of the search space irrespective of the initialisation approach, resulting in wasted search effort. It is also shown that random initialisation increases the number of roaming particles, and that this has a negative impact on convergence time. It is also shown that enforcing a boundary constraint on personal best positions does not help much to address this problem. The main objective of the article is to show that the best approach is to initialise particles to zero, or random values close to zero, without imposing a personal best bound.

Leadership small number of agents initialised at a single point. The objective is to achieve an even distribution of agents to tasks. To address this problem, this paper proposes a new method that endows agents with models of motivation and leadership to aid their coordination. The proposed approach uses the Particle Swarm Optimisation algorithm with a ring neighbourhood topology as a foundation and incorporates computational models of motivation to achieve the goals of task allocation more effectively. Simulation results show that, first, the proposed method increases the number of tasks discovered. Secondly, the number of tasks to which the agents are allocated increases. Thirdly, the agents distribute themselves more evenly among the tasks.

Analysis and Evolutionary Computing Model Based Evolutionary Computation and Its Application elements running multiple concurrent applications will become a reality. The heterogeneous multicluster architecture enables to cope with the challenging hardware/software requirements presented by such systems. This paper shows principles and optimization of multicluster dimensioning aiming at an appropriate distribution of applications onto clusters containing different types of processing elements. The approach represents an initial exploration phase efficiently finding a suitable multicluster configuration in the large design space. Hence, results should be further refined by more accurate but less time-efficient simulation-based techniques. As the starting point, a parallelism value matrix is analytically extracted describing application mappings independently on the architecture and scheduling. A genetic algorithm (GA) and a mixed-integer linear programming (MILP) approach solving the dimensioning problem are introduced and compared. Both solutions use the parallelism value matrix as input. Scalability results show that the GA generates results faster and with a satisfactory quality relative to the found MILP solutions. Finally, the dimensioning approach is demonstrated for a realistic benchmark scenario.

Multiprocessor System-on-Chips via Evolutionary Computing Model Based Evolutionary Computation and Its Application intellectual property (IP) cores onto a multiprocessor system-on-chip (MPSoC). The MPSoC is statically scalable in terms of number of IP cores and an 1-ary n-mesh network-on-chip (NoC). The approach places more affine IP cores closer to each other and affinity is based on an amount of exchanged communication and administration data. Assuming ideal network conditions, accounting for execution latency, separate affinity value matrices for communication and administration are extracted from the application mappings. Aiming at better system performance, the goal is to find a reasonable trade off between communication and administration affinity. Hence, both matrices are merged into a single affinity value matrix based on linear weighting. A genetic algorithm (GA) and a mixed-integer linear programming (MILP) solution use the weighted affinity value matrix to efficiently map IP cores onto a NoC. A scalability analysis shows that the GA generates results faster and with a satisfactory quality relative to the found MILP solutions. Realistic benchmark results demonstrate that a tradeoff between administration and communication affinity significantly reduces administration latency improving application performance. As network size and system adaptability increase, the growing influence of administration becomes more evident.

recently developed optimization algorithms lose their efficiency when the dimensionality of the problems increases. Decomposing a large scale problem into smaller subproblems overcomes this drawback. However, if the large scale optimization problem contains dependent variables, they should be grouped into one subproblem to avoid a decrease in performance. In this paper, the Dependency Identification with Memetic Algorithm (DIMA) model is proposed for solving large scale optimization problems. The Dependency Identification (DI) technique identifies the best arrangement to group the dependent variables into smaller scale subproblems. These subproblems are then evolved using a Memetic Algorithm (MA) with a proposed self-directed Local Search (LS). As the subproblems of a nonseparable large scale problem may contain interdependent variables, the proposed model, DIMA, uses an Information Exchange Mechanism to maintain one value for all the instances of any independent variable in the different subproblems. A newly designed test suite of problems has been developed to evaluate the performance of DIMA. The first evaluation shows that the DI technique is competitive to other decomposition techniques in the literature in terms of consuming less computational resources and better performance. Another evaluation shows that DI makes the optimization of a decomposed large scale problem using DIMA as powerful as the optimization of a complete large scale problem using MA. This makes DIMA a promising optimization model for optimization problems which can be 10 times larger (or more) than the large scale optimization problems under consideration in this paper.

modern, real-coded genetic algorithm. Our proposal is tested on 16 registration scenarios involving

real-world MRI medical images. A novel methodological framework to compare heterogeneous IR algorithms is also described. Following such methodology, our algorithm is compared with four well-known IR techniques of different natures. The proposed method is able to improve the results of these techniques in the majority of the scenarios.

Feature Extraction functionals applied on the image function. When the functional is integral, it becomes identical to the well-known Radon transform, which is a useful tool in computed tomography medical imaging. The key question in Trace transform is to select the best combination of the Trace functionals to produce the optimal triple feature, which is a challenging task. In this paper, we adopt a multi-objective evolutionary algorithm adapted from the elitist nondominated sorting genetic algorithm (NSGA-II), an evolutionary algorithm that has shown to be very efficient for multi-objective optimization, to select the best functionals as well as the optimal number of projections used in Trace transform to achieve invariant image identification. This is achieved by minimising the within-class variance and maximising the between-class variance. To enhance the computational efficiency, the Trace parameters are calculated offline and stored, which are then used to calculate the triple features in the evolutionary optimization. The proposed Evolutionary Trace Transform (ETT) is empirically evaluated on various images from fish database. It is shown that the proposed algorithm is very promising in that it is computationally efficient and considerably outperforms existing methods in .

automatically splitting video frames based on the content. A GP methodology is presented to show how to evolve a program which can analyse the difference between scenes and split them accordingly. A few different approaches have been investigated in this study. Compared with human written video splitting programs, GP generated splitters are more accurate. Moreover, it is shown that these video splitting programs have high tolerance to noises. They can still achieve reasonable performance even when the videos are not easily recognisable by eyes due to the server artificial noises.

years. However, it takes too much time for evolutionary algorithms to generate circuits directly. Recently, the repair technique has been introduced into evolutionary design of the circuit to significantly decrease the time cost. And yet, the repair technique costs a lot of gate resource. In this paper, the evolutionary repair for evolutionary design of the combinational circuit is proposed, which generates the repair circuits with an evolutionary algorithm. The evolutionary repair could reduce the gate resource cost and does not spend much more time. The evolutionary repair is merged into the traditional evolutionary algorithm to form a novel evolutionary design algorithm, i.e. the erEDA. The experimental results demonstrate that the erEDA could balance the time cost and the gate resource consumption.

Architectures and Systems, Evolutionary Computer Vision, Evolvable hardware and software multifunctional gates such as polymorphic gates or multiplexed ordinary gates. The design procedure is based on evolutionary design and optimization conducted using Cartesian genetic programming (CGP). Because of the complexity of the problem the design is decomposed to two phases. In the first step, a multifunctional filter is evolved at the register-transfer level (RTL) using a set of processing elements containing functions such as minimum/maximum, minimum/average etc. over two pixels. In the second step, gate-level implementations of the processing elements used in evolved filters are designed and optimised using CGP in combination with conventional logic synthesis tools. It is shown that resulting filters exhibit good filtering capabilities. They are also area-efficient in comparison with solutions based on multiplexing of ordinary filters.

Richardson-Lucy Algorithm Richardson-Lucy (RL) algorithm is a deconvolution algorithm that can restore the original image quite well if the point-spread function (PSF) is known. However, it needs to know the PSF to apply this algorithm. In this paper, by restricting our problem to motion-blurred line images, we propose a blind-deconvolution algorithm by estimating PSF using Differential Evolution. As the fitness value, we define a weighted sum of two kinds of error functions. Numerical examples will show the effectiveness of the proposed algorithm.

Problem technique, as a presently state-of-the-art method, with a recently proposed adapted version of the Bacterial Evolutionary Algorithm (BEA) in order to efficiently solve the Permutation Flow Shop Problem. The obtained techniques are evaluated via simulation runs carried out on the well-known Taillard's benchmark problem set. Based on the experimental results the hybrid methods are compared to each other and to the original techniques (i.e. to the original IG and BEA algorithms).

Resource-Constrained Project Scheduling in recent years due to their practical implications. In real-world applications, a problem is usually confronted with multiple types of uncertainties that are incommensurable with each other. Decision makers in the real-world do not trade-off objectives alone, but also and more importantly trade-off different uncertainties. The contemporary optimization

techniques that deal with uncertainty generally treat different types of uncertainties by aggregating them into a single form. In this paper, we introduce a new type of optimization problems which are characterised by multiple conflicting uncertainties. We term them as multi- uncertainty optimization problems. Modelling multiple conflicting uncertainties as an optimization problem can provide analysts a powerful tool to search non- dominated solutions in a risk space in addition to the objective space. This is particularly useful since sources of uncertainties are usually uncontrollable and cannot be optimised as objectives. The concept of a risk operating curve is introduced which provides a unique perspective of the problem to the decision makers allowing them to opt for solutions based on their risk attitude toward different sources of uncertainties. The application of these concepts is demonstrated through a test problem in the resource-constrained project scheduling domain.

Problem Using a Hybrid Evolutionary Algorithm optimization., Convergence, scalability and complexity analysis combining several mutation operators some of which are meant to implement stochastically a well known technique designed for the specific problem in question while some others playing the role of random search, have become rather popular for tackling various NP-hard optimization problems. While empirical studies demonstrate that hybrid evolutionary algorithms are frequently successful at finding solutions having fitness sufficiently close to the optimal, many fewer articles address the computational complexity in a mathematically rigorous fashion. This paper is devoted to a mathematically motivated design and analysis of a parametrised family of evolutionary algorithms which provides a polynomial time approximation scheme for one of the well-known NP-hard combinatorial optimization problems, namely the single machine scheduling problem without precedence constraints. The authors hope that the techniques and ideas developed in this article may be applied in many other situations.

evolutionary algorithms, either to promote diversity, or in an archiving mechanism, or in the selection process. The usual requirement is to determine which point in a set contributes least to the hypervolume of the set, so that that point can be discarded. We describe a new exact algorithm IWFG for performing this calculation that combines two important features from other recent algorithms: the bounding trick from WFG, that accelerates calculations by generating lots of dominated points; and the best-first queueing mechanism from IHSO, that eliminates much of the calculation for most of the points in a set. Empirical results show that IWFG is significantly faster than IHSO on much experimental data in five or more objectives.

problem: A modified MOEA with an epigenetic silencing metaphor governing bodies demand more accountability and transparency in management practices that simultaneously guarantee sustainable production of goods and continued provision of ecosystem services (i.e., public goods with no markets, such as clean air). In this paper we demonstrate the futuristic form of decision making that will assist in meeting some of these challenges in ensuring sustainability in land use management. We apply a modified Multi- Objective Evolutionary Algorithm (MOEA), influenced by epigenetic silencing, to a farm case study. The result is a set of time-series, farm management strategies and their related spatial arrangements of land uses that satisfy 14 incommensurable and sometimes conflicting objectives, and spatial constraints. The 14 objectives cover economic (i.e. productivity and financials) and environmental issues. Choosing a single strategy from the set for implementation will require social-ethical value judgement determined from preferences and values of multiple decision-makers. This part of the decision making process is beyond the scope of this paper, but will contribute to ongoing research which will make it possible to fully account for the Triple Bottom Line (TBL), characterised by environmental, economic and social elements.

uncertain environments., Heuristics, metaheuristics and hyper-heuristics which performs based on population and stochastic search contributed to solve optimization problems. This algorithm has been applied in various applications e.g. data clustering, neural networks learning, nonlinear function optimization, etc. Several problems in real world are dynamic and uncertain, which could not be solved in a similar manner of static problems. In this paper, for the first time, a modified artificial fish swarm algorithm is proposed in consideration of dynamic environments optimization. The results of the proposed approach were evaluated using moving peak benchmarks, which are known as the best metric for evaluating dynamic environments, and also were compared with results of several state-of-the-art approaches. The experimental results show that the performance of the proposed method outperforms that of other algorithms in this domain.

Constrained Optimization search operator to the modified bacterial foraging algorithm (MBFOA) to solve constrained optimization problems. The adaptive stepsize is used in the chemotactic loop for each bacterium to promote a suitable sampling of solutions and the local search operator aims to

promote a better trade-off between exploration and exploitation during the search. Three MBFOA variants, the original one, another with only the adaptive stepsize and a third one with both, the adaptive stepsize and also the local search operator are tested on a set of well-known benchmark problems. Furthermore, the most competitive variant is compared against some representative nature-inspired algorithms of the state-of-the-art. The results obtained provide evidence on the utility of each added mechanism, while the overall performance of the approach makes it a viable option to solve constrained optimization problems.

constraints which are complex implicit functions of the design variables. Frequently, such constrained problems are replaced by unconstrained ones by means of penalty functions. A family of adaptive penalty schemes for steady-state genetic algorithms is proposed here. For each constraint, a penalty parameter is adaptively computed along the run according to information extracted from the current population, such as the existence of feasible individuals and the level of violation of each constraint. The performance of each variant in the family is examined using test problems from the evolutionary computation as well as mechanical and structural optimization literature.

Model-building GA proportion-weighted combination is the same as the given benchmark portfolio. However, the benchmark portfolio generally opens only the return to the public but other information such as the assets included in the portfolio, the proportion-weighted combination, the rebalancing date and the investment strategies is closed to the public. In order to optimise such portfolios, we propose an optimization method based on the probabilistic model-building GA in this paper. On the other hand, we are focusing on the long-short portfolio optimization. The long-short portfolio consists of the assets with long positions in which they have bought and been held and with short positions in which they have been borrowed and sold. While applying any optimization method to the long-short portfolios, the portfolio as a feasible solution must be satisfied an equality constraint. In order to make the feasible solutions effectively, we propose two techniques and then apply them to our optimization method. In the numerical experiments, we show that our method has better ability to replicate the long-short portfolios with good fitness values. We found that, however, some portfolios were not replicated though our method worked well. We also discuss this problem in this paper.

Optimization with Dynamically Varying Neighborhood Technique digital FIR filter using swarm and evolutionary algorithms. Classical gradient based approaches are not efficient enough for accurate design and thus evolutionary approach is considered to be a better choice. In this paper a hybrid of Genetic Algorithm and Particle Swarm Optimisation algorithm with varying neighbourhood topology, namely Genetic Lbest Particle Swarm Optimisation (PSO) with Dynamically Varying Neighbourhood (GLPSO DVN) is used to find the filter coefficients. In this work two objective functions (error metrics) are minimised. The first one is based on stop and pass band ripple and the second one studies the mean square error between the ideal and actual designed filter. The hybrid algorithm is found to produce fitter candidate solution than the classical Lbest PSO. The results are compared with the results obtained by solving the same problem using Lbest PSO (LPSO). It is also observed that GLPSO DVN gives better results than LPSO and as well LPSO DVN.

hyper-heuristics, Memetic, multi-meme and hybrid algorithms technique, mimics the well-informed swarming behaviour of social species. A simple and effective searching strategy declares PSO as a potential member for solving various optimization problems. The present study embeds the concept of chaos at different stages of PSO, intending to enhance the convergence speed while trying to avoid stagnation and maintaining the solution quality. The proposed PSO variant is termed as Totally disturbed PSO (TDPSO). The algorithm starts with a disturbed (chaotic) population, generated by considered chaotic system. Thereafter, when a certain number of iterations have elapsed and the searching process approaches equilibrium state, a relative velocity index is calculated for each particle to evaluate its present state and to decide whether or not the particle needs perturbation. The efficacy of proposed algorithm is tested against a set of benchmark problems and results are compared with existing Chaotic PSO and a standard PSO variant. Numerical results manifest that TDPSO works better over considered existing variants by effectively enhancing the searching capability and precision as well.

Scheduling Problem and combinatorial optimization. ideas with Particle Swarm Optimisation has been proposed and tested in the context of degree constrained minimum spanning trees. This paper investigates the applicability of the new hybrid meta-heuristic to a challenging scheduling problem. The resource constrained scheduling problem involves a set of jobs that need to be scheduled on multiple machines so as to minimise total weighted tardiness in the presence of precedence constraints

and release dates. This is further complicated by the need for the jobs to consume a shared resource with limited capacity. The paper shows that the Lagrangian Particle Swarm Optimisation approach can produce both high quality upper bounds (heuristic solutions) and useful lower bounds giving a performance guarantee for these heuristic solutions. Computational results are presented to show that the new method can outperform previous approaches in the literature for this problem.

attention, and yet most work in this area is focused on Tracking Moving Optimum (TMO), which is to optimise the current fitness function at any time point. Recently, we proposed a more practical way to solve dynamic optimization problems, which is referred to as Robust Optimisation Over Time (ROOT). In ROOT, we are trying to find solutions whose performances are acceptable over more than one environmental state, i.e., fitness functions. Before any development of benchmarks or algorithms for ROOT, it is necessary to have some understanding of what aspects of an environment can change and more importantly how these changes influence the solving of ROOT problems. In this paper, we develop a number of measures which can be used to characterise and analyse the underlying changing environment in the framework of ROOT. We test these measures on several benchmark problem instances, and it is shown that these measures are able to differentiate different dynamics effectively and provide useful information about what kind of algorithms might or might not suit certain dynamic environments.

Environments optimization Swarm Optimisation (PSO) is proposed in this paper for dynamic optimization problems. The multi-population strategy is used to enhance the diversity and keeps each subpopulation on a different peak, and then a hybrid operator based on DE and PSO (DEPSO) is designed to find and track the optima for each subpopulation. Using DEPSO operator, each individual in subpopulations is sequentially carried out DE and PSO operations. An exclusion scheme is proposed which integrates the distance based exclusion scheme with hill-valley function. The algorithm is applied to Moving Peaks Benchmark (MPB) problem. Experimental results show that it is significantly better in terms of averaged offline error than other state-of-the-art algorithms.

Video Data analysis and data mining streams. The proposed scheme aims to transform a given sequential stream into a dependency structure of particle populations. Each particle population summarises an associated segment. The novel point of the proposed scheme is that both of dependency learning and segment symmetrisation are performed in an unsupervised online manner without assuming priors. The proposed scheme is executed in two-stage learning. At the first stage, a segment corresponding to a common dominant image is estimated using evolutionary particle filtering. Each dominant image is depicted based on combinations of image descriptors. Prevailing features of a dominant image are selected through evolution. Genetic operators introduce the essential diversity preventing sample impoverishment. At the second stage, transitional probability between the estimated segments is computed and stored. The proposed scheme is applied to extract dependencies in an episode of a TV drama. We demonstrate performance by comparing to human estimations.

Evolution optimization model of woody plants (trees) reconstruction by multi-objective optimization. Reconstruction of a parametrised procedural model from imagery is addressed by a multi-objective differential evolution algorithm, which evolves a parametrised procedural model by fitting a set of its rendered images to a set of given projected images using bi-objective comparisons made on a pixel level of the images. The use of multi-objective approach gives the decision maker a chance to select the final resulting model, and helps determine the optimization criteria tradeoff weights for later production.

Multi-Object Tracking optimization. research area. It is a challenging problem mainly due to the frequent occlusions and interactions that happen between the multiple targets. We formulate the multiple interaction problem as an optimization problem and explore Particle Swarm Optimisation (PSO) algorithm for the optimal solution. To tackle the problem of premature convergence, we present a new hybrid PSO that incorporates a differential evolution mutation operation with a Gaussian based PSO. Furthermore, by exploiting the specific structure of multiple object interactions, we introduce a cooperative strategy into the proposed PSO for more efficient searching and for conquering the curse of dimensionality. With patch-based observation models, our method can robustly handle significant occlusions and interactions.

Conflict of Interest Papers of machine vision and image analysis such as remote sensing and face recognition. One of the challenges in image classification is finding an optimal set of features for a particular task because the choice of features has direct impact on the classification performance. However the goodness of a feature is highly problem dependent and often domain knowledge is required. To address these issues we introduce a Genetic Programming (GP) based image classification method,

Two-Tier GP, which directly operates on raw pixels rather than features. The first tier in a classifier is for automatically defining features based on raw image input, while the second tier makes decision. Compared to conventional feature based image classification methods, Two-Tier GP achieved better accuracies on a range of different tasks. Furthermore by using the features defined by the first tier of these Two-Tier GP classifiers, conventional classification methods obtained higher accuracies than classifying on manually designed features. Analysis on evolved Two-Tier image classifiers shows that there are genuine features captured in the programs and the mechanism of achieving high accuracy can be revealed. The Two-Tier GP method has clear advantages in image classification, such as high accuracy, good interpretability and the removal of explicit feature extraction process.

Optimization Problems was first designed for solving single objective optimisations problems is extended to solve Multi-objective optimization problems with constraints. Through analysis, novel pbest and lbest updating criteria which are more suitable for solving Multi-objective optimization problems are proposed. By combining the external archive and the novel updating criteria, excellent performance is achieved by DMS-MO-PSO on eight benchmark test functions.

Many-Objective Problems in Particle Swarm Optimization algorithms, Particle swarm optimization multi-objective meta-heuristic inspired on animal swarm intelligence. It is used to solve several Multi-Objective Optimization Problems (MOPs), problems with more than one objective function. However, Multi-Objective Evolutionary Algorithms (MOEAs), including MOPSO, have some limitations when the number of objective grows. Many-Objective Optimization research methods to decrease the negative effect of applying MOEAs into problems with more than three objective functions. In this context, the goal of this work is to explore several archiving methods from the literature used by MOPSO to store the selected leaders into Many-Objective Problems. Moreover, new archiving methods are proposed specially for these problems. The use of the archiving methods into MOPSO is evaluated through an empirical analysis aiming to observe the impact of these methods in the convergence and the diversity to the Pareto front, in Many-Objective scenarios.

algorithms, Particle swarm optimization Algorithms (MOPSO) is the deterioration of its search ability when the number of objectives scales up. In the literature some techniques were proposed to overcome these limitations, however, most of them focuses on alternatives to the non-domination relation. In this work, a different direction is explored, and some specific aspects of MOPSO as the selection of the leaders to guide the search are investigated. The work presents a comparison of several approaches of leader selection to find which of them presents the better results in terms of convergence and diversity in many-objective scenarios. Also, a new method, called Opposite method, is proposed. The results are analysed through different quality indicators and statistical tests.

size is proposed based on a representation for the quantum images. The similarity value is estimated according to the probability distribution of the results from quantum measurements. The proposed method is fast because a single operation can transform the entire information encoded in two images simultaneously. Two simulation-based experiments, which provide a reasonable estimation to the quantum images' similarity, are implemented using Matlab on a classical computer by means of linear algebra with complex vectors as quantum states and unitary matrices as unitary transformations. It also opens the door towards image searching from a database on quantum computers.

This paper describes an algorithm to find all quantum templates with 3 qubits. The algorithm is used to find all templates with up to 8 gates. The method first finds a quantum identities of 3 qubits, template matching is used to verify if the identity is a template. Experiments show the significance of templates the new to reduce the quantum costs of benchmark circuits.

private key between one and many parties based on four single-qubit states. The qubit capacity of this protocol is high due to the absence of bit wise exclusive OR of qubits' measuring results. It is also feasible with present-day technology, even when a great many participants are engaged, and secure against several common attacks. Besides, this protocol can be directly extended to deal with the many-to-many situation.

(IMCA) is proposed in the paper. IMCA combines Immune Clone Selection and Memetic algorithm; Two populations are used in the evolutionary process. Clone reproduction and selection, Memetic mutation, crossover, individual learning and selection are adopted to evolve the two populations. After watershed proceeding, extracting the texture features of an image and encoding them with real numbers, IMCA is used to partition these features, and the final segmentation result is obtained. This approach is applied to segment three types of images, including artificial synthetic texture images, natural images, and SAR images, the experimental results show the effectiveness of the proposed

algorithm.

Systems clustering, data analysis and data mining high accuracies and steadiness. The models developed to achieve this are usually complex and computationally expensive. In this paper, we propose an unsupervised multi-layered artificial immune system for an insurance classification problem that is characterised as highly dimensional and contains escalating missing data. The system is compared with the k-nearest neighbour, support vector machines and logistic discriminant models. The results show that whilst k-nearest neighbour achieves the highest accuracy overall, the multi-layered artificial immune system is steady and maintains high performance overall compared to other models, regardless of the missing data pattern.

constrained optimization problems, inspired by the principle of the vertebrate immune system. The analogy between the mechanism of vertebrate immune system and constrained optimization formulation is first given. The population is divided into two groups: feasible individuals and infeasible individuals. The infeasible individuals are viewed as the inactivated immune cells approaching the feasible regions by decreasing the constraint violations whereas the feasible individuals are treated as activated immune cells searching for the optima. The interaction between them through the extracted directional information is facilitated mimicking the functionality of T cells. This mechanism not only encourages infeasible individuals approaching feasibility regions, but facilitates exploring the boundary between the feasible and infeasible regions in which optima are often located. This approach is validated and performance is quantified by the benchmark functions used in related researches through statistical means with those of the state-of-the-art from various branches of evolutionary computation paradigms. The performance obtained is fairly competitive and in some cases even better.

trended towards Adaptive PSO (APSO). APSO changes its behaviour during the optimization process based on information gathered at each iteration. It has been shown that APSO is able to solve a wide range of difficult optimization problems efficiently and effectively. In classical PSO, all parameters remain constant for the entire swarm during the iterations. In particular, all particles share the same settings for their velocity weights. We propose a Step-Optimised PSO (SOPSO) algorithm in which every particle has its own velocity weights and an inner PSO iteration is used to take a step towards optimising the settings of the velocity weights of every particle at every iteration. We compare SOPSO to four known PSO variants (global best PSO, decreasing weight PSO, time-varying acceleration coefficients PSO, and guaranteed convergence PSO). Experiments are conducted to compare the performance of SOPSO to the known PSO variants on 22 benchmark problems. The results show that SOPSO outperforms the known PSO variants on difficult optimization problems that require large numbers of function evaluations for their solution. This suggests that the SOPSO strategy of optimising the settings of the velocity weights of every particle improves the robustness and performance of the algorithm.

distribution tracking with exponential forgetting integration of PSO variants in adaptive, or self-adaptive schemes, in an attempt to aggregate their characteristics and their search dynamics. In this work we borrow ideas from adaptive filter theory to develop an online algorithm adaptation framework. The proposed framework is based on tracking the parameters of a multinomial distribution to capture changes in the evolutionary process. As such, we design a multinomial distribution tracker to capture the successful evolution movements of three PSO variants. Extensive experimental results on ten benchmark functions and comparisons with five state-of-the-art algorithms indicate that the proposed framework is competitive and very promising. On the majority of tested cases, the proposed framework achieves substantial performance gain, while it seems to identify accurately the most appropriate algorithm for the problem at hand.

global optimum in a continuous problem space, at least a very good position and doing this at modest computational cost. However, as the number of possible local optima increases, PSO will only explore a subset of these positions. Techniques such as niching can allow a small number of positions to be explored in parallel but once a problem has become truly deceptive (has many optima) there is little choice but to sequentially explore local optima. PSO, once converged, has no way of dispersing its particles so as to allow further exploration necessary to find a new optimum. Random restarts are a commonly used way of providing this divergence, this paper suggest another technique inspired by Extremal Optimisation (EO). The proposed technique allows particles to disperse by way of positions that are fitter than average. After a while this dispersion ceases and PSO takes over again, but since it starts from better than the average fitnesses than would have been found randomly, the point it converges to is also better. This alternation of algorithms can carry on indefinitely. This paper

examines the performance of sequential PSO exploration on a range of problems, some deceptive, some non-deceptive. As predicted, performance on deceptive problems tends to improve significantly over time while performance on non-deceptive problems, which do not have multiple positions with comparable fitness to spread through, does not.

Optimisation Problems algorithms, Large-scale problems. solving optimisation problems. To define a configuration of an EA several components and parameters must be specified. Therefore, one of the main drawbacks of EAs is the complexity of their parameter setting. Another problem is that EAs might have a tendency to converge towards local optima for many problems. For this reason, several methods to deal with local optima stagnation have been designed. M, which consists in the reformulation of mono-objective problems as multi-objective ones, is one of such methods. Some multiobjectivisation methods require the specification of parameters by the user. In some cases, the quality of the obtained solutions has been improved by these methods. However, they usually introduce more components and parameters into the optimisation scheme. The main contribution of this work is to deeply analyse the robustness of m approaches with parameters. Several large scale continuous optimisation problems have been m in order to perform such a study. Extracted conclusions might allow designing methods which profit from m with parameters, without incorporating additional parameters to the whole optimisation scheme. By this way, the parameter setting could be performed in an easier way. The experimental evaluation has provided promising results.

Optimization of Gene Regulatory Network Models algorithms, Biometrics, bioinformatics and biomedical applications evolutionary approach is proposed for the optimization of gene regulatory network models. The approach is presented based on the neglected observations in GRN optimization that (i) structural dependencies exist among objectives; and (ii) some objectives may be more important than others. The hierarchical Pareto dominance is able to reduce the number of objectives during optimization process and increase the selection pressure to relieve the many objective problem. The proposed hierarchical Pareto dominance based multi-objective approach is verified and compared with classical Pareto dominance based algorithm NSGAII on the gene regulatory network optimization problem. The results obtained indicate that the presented approach has great performance when no noise exist. Also it shows superior results compared to NSGAII.

Hybridised MOGA algorithms, Evolutionary games and multi-agent systems for a morphing Unmanned Aerial Vehicle (UAV) aerofoil/wing shape design optimisation. The first CIS uses Genetic Algorithm (GA) and the second CIS uses Hybridised GA (HGA) with the concept of Nash-Equilibrium to speed up the optimisation process. During the optimisation, Nash-Game will act as a pre-conditioner. Both CISs; GA and HGA, are based on Pareto optimality and they are coupled to Euler based Computational Fluid Dynamic (CFD) analyser and one type of Computer Aided Design (CAD) system during the optimisation. For the practical test case, one type of morphing techniques; Leading and Trailing Edge Deformation (LTED) is considered to control flow over the aerofoil/wing. LTED to a Natural Laminar Flow (NLF) aerofoil is applied to maximise the lift coefficients (Cl) at both the take-off and landing conditions. Two applications on LTED with low/middle and high design complexities are optimised using GA and HGA. The optimisation efficiency for GA and HGA are compared in terms of computational cost and design quality. Numerical results clearly show that Nash-Game helps a GA based CIS to accelerate the optimisation process and also to produce higher performance solutions in solving both the low/middle and high complex design optimisation problems. In addition numerical CFD study demonstrates that the implementation of morphing technique on the aerofoil/wing significantly improves the lift coefficients at both the take-off and landing conditions when compared to the baseline design.

on Bell Measurement authentication is proposed, where unitary operations are not necessary, while they are indispensable in other quantum direct communication (QDC) schemes. Since the realisation of a unitary operation is not a simple task in quantum computation and quantum communication, it simplifies the implementation of QDC schemes to a great extent. The scheme is partitioned into two parts, mutual authentication and direct communication. To authenticate identities of the two users, an authentication strategy is put forward by using the property of Bell states in which unitary is not performed. In direct communication phase, Alice and Bob can communicate directly and deterministically without any unitary operation due to the property of entanglement swapping. Naturally, the security of the presented DSQC scheme is discussed in detail. Compared with the previous QDC protocols, the proposed DSQC scheme has some meaningful advantages.

Gaussian mutation that is not directed toward the optimum. Additionally, self-adaptation mechanism

is used in the standard ES to adapt mutation step-size. This paper presents a new evolution strategy which is called Quantum-inspired Evolution Strategy (QES). QES applies a new learning mechanism whereby the information of the mutants is used as a feedback to adapt the mutation direction and step-size simultaneously. To demonstrate the effectiveness of the proposed method, several experiments on a set of numerical optimization problems are carried out and the results are compared with the standard ES and Covariance Matrix Adaptation ES (CMA-ES) which is the state-of-the-art method for adaptive mutation. The results reveal that QES is superior to standard ES and CMA-ES in terms of convergence speed and accuracy.

data mining Discovery in Databases. Many algorithms can perform clustering in a simple and efficient manner, but have drawbacks, such as the lack of a way to automatically determine the optimal number of clusters in the dataset and the possibility of getting stuck in local optima solutions. To try and reduce these drawbacks this work proposes a new clustering algorithm based on Artificial Immune Systems. This algorithm is characterised by the generation of multiple simultaneous high quality solutions in terms of the number of clusters in the database and the use of a cost function that explicitly evaluates the quality of clusters, minimising the inconvenience of getting stuck in local optima solutions.

Operations combinatorial optimization. transported between ports, playing a central role in international trade. Consequently, ships grew in size in order to maximise their container transportation capacity in each trip. Due to increasing demand, container terminals face the challenges of increasing their service capacity and optimising the loading and unloading time of ships. This paper presents the proposal of a novel meta-heuristic based on the Clonal Selection Algorithm, named MRCLONALG, to minimise the number of reshuffles in operations involving piles of containers. The performance of the proposed model was evaluated through simulations and results compared with those obtained by algorithms from the literature under the same test conditions. The results show that MRCLONALG is competitive in terms of minimising the need of reshuffles, besides presenting a reduced processing time compared with models of similar performance.

Credit Risk Assessment Applications Intelligence: an alternative approach to solve computational intelligence problems. Despite their interesting properties and theoretical appeal, the AIS algorithms still require a broader experimentation in real and large scale problems to ensure that they can approximate or outperform the more traditional approaches. In this work, the two known AIS models SAIS and CLONALG are studied in the problem of credit risk analysis making use of three benchmarking databases for comparative analysis. Further variations of the initially proposed algorithms are experimented and their performance are compared to classic logistic regression with respect to the KS (Kolmogorov-Smirnov) test and ROC curves. Also, a method for score computation is introduced for allowing a more robust analysis through the ROC and KS metrics. The results can shed some light into the potential of using AIS models in daily real-world credit risk assessment operations.

multi- objective (MO) version of a recently created single objective (SO) optimization algorithm called the Alliance Algorithm (AA). The algorithm is based on the metaphorical idea that several tribes, with certain skills and resource needs, try to conquer an environment for their survival and to ally together to improve the likelihood of conquest. The AA has given promising results in several fields to which has been applied, thus the development of a MO variant (MOAA) is a natural extension. Here the MOAA's performance is compared with two well-known MO algorithms: NSGA-II and SPEA-2. The performance measures chosen for this study are the convergence and diversity metrics. The benchmark functions chosen for the comparison are from the ZDT and OKA families and the main classical MO problems. The results show that the three algorithms have similar overall performance. Thus, it is not possible to identify a best algorithm for all the problems; the three algorithms show a certain complementarity because they offer superior performance for different classes of problems.

Multi-objective Multiple Traveling Salesman Problem algorithms, Multiobjective optimization generalisation of the classical multi-objective travelling salesman problem. In this paper, a formulation of the MmTSP, which considers the weighted sum of the total travelling costs of all salesmen and the highest travelling cost of any single salesman, is proposed. An estimation of distribution algorithm (EDA) based on restricted Boltzmann machine is used for solving the formulated problem. The EDA is developed in the decomposition framework of multi-objective optimization. Due to the limitation of EDAs in generating a wide range of solutions, the EDA is hybridised with the evolutionary gradient search. Simulation studies are carried out to examine the optimization performances of the proposed algorithm on MmTSP with different number of objective functions, salesmen and problem sizes.

Data Mining to implement and performs well on various optimization problems. However, PSO is sensitive to initialisation due to its rapid convergence which leads to the lack of population diversity and premature convergence. To solve this problem, a jumping-out strategy named crown jewel defence (CJD) is introduced in this paper. CJD is used to relocate the global best position and reinitialise all particles' personal best position when the swarm is trapped in local optima. Taking the advantage of CJD strategy, the swarm can jump out of the local optimal region without being dragged back and the performance of PSO becomes more robust to the initialisation. Experimental results on benchmark functions show that the CJD-based PSOs are comparable to or better than the other representative state-of-the-art PSOs.

in CNC Machining Centers using New Binary PSO Engineering applications problem concerning various issues such as Part mix, Tool allocation and Process plans in CNC machining centers. The mathematical formulation of considered selection problem emerges as highly constrained and 0-1, combinatorial optimization, which further belongs to the category of NP-hard problems. The proposed Binary PSO variant embeds a new sigmoid function namely Gompertz function as a binary number generator with an additional benefit of controlling its parameters so as to induce the combined effect of sigmoid as well as linear function. The corresponding variant is termed as Gompertz Binary Particle Swarm Optimization (GBPSO). Before applying GBPSO for considered selection problem, the efficacy of proposed GBPSO is tested on a set of 0-1 Multi-dimensional knapsack problems and results are compared with standard binary PSO. Thereafter two test cases for considered optimal selection problem are solved and analysed using GBPSO. The simulation results manifest the superiority of proposed variant over standard BPSO for solving benchmark problems and practical application as well.

Intelligence in Data Mining (MBPSO) based on a new updating strategy. Unlike the traditional binary PSO, which updates the binary bits of a particle ignoring their previous status, MBPSO memorises the bit status and updates them according to a new defined velocity. As such, precious historical information could be retained to guide the search. The velocity vector of MBPSO is designed as a probability for deciding whether the particle bits change or not. The proposed algorithm is tested on four discrete benchmark functions. The experimental results reported over 100 runs show that MBPSO is capable of obtaining encouraging performance in discrete optimization problems.

Basically it consists of three operations: mutation, crossover and selection. Despite many research papers dealing with the first two, hardly any attention has been paid to the third one nor is there a place for this operation in the algorithm basic naming scheme. In the paper we show that employing different selection strategies combined with some random perturbation of population vectors notably improves performance in high-dimensional problems. Further analysis of results shows that the improvement is statistically significant.

algorithm. It contains three parameters which need to be predefined by users. These parameters are sensitive to specific problems and difficult to set. Opposition-based computing (OBC) is a new scheme for computational intelligence. OBC is helpful to existing techniques by making better decisions through simultaneous consideration of entities and opposite entities. The opposition phenomenon exists in the literature concerning parameter control of DE. In this paper, OBC is employed to assist with the solving of parameter control problem in DE. Employing OBC to parameter control problem in DE has not been reported previously to our knowledge. The proposed approach is called opposition-based adaptive DE (OADE). It uses two pools to respectively store parameters and opposite parameters. The parameters and their opposites are used at the same time to generate trial vectors in DE. During the evolutionary process, fitness improvement at a generation serves as a filter to detect proper parameters for optimization problems. The detected proper parameters and their opposites are stored in pools, whereas the improper parameters and their opposites are replaced by new randomly generated ones. The use of parameters and their opposites can balance the exploration and exploitation behaviour of DE in one generation. The performance of OADE is compared with three other DE algorithms. The experimental results show that OADE significantly outperforms the benchmark algorithms. Moreover, OADE is not sensitive to the pool size.

is based on the paradigm of the self-organising maps (SOM) and competitive neural networks. The proposed algorithm is population based and a mutation and a selection operators are defined in analogy to standard evolutionary algorithms (EAs). In the proposed scheme the individuals move in the search space following the dynamics of a modified version of the SOM, which is based on a discrete dynamical filter. The proposed approach tries to take advantage of the explorative power of the SOM, and defines a new search strategy which is based on a combination of a local task and a global task,

using neighbourhood interactions. The proposed algorithm performance is compared with standard and state of the art variants of differential evolution (DE) algorithm. Wilcoxon tests show that the proposed algorithm is competitive with DE, advantages and disadvantages are outlined.

multi-meme and hybrid algorithms multiobjective optimization. The evolutionary strategy uses distance based aggregate surrogate models in two ways: as a part of memetic search and as way to pre-select individuals in order to avoid evaluation of bad individuals. The model predicts the distance of individuals to the currently known Pareto set. The newly proposed algorithm is compared to other algorithms which use similar surrogate models on a set of benchmark functions.

multi-objective genetic algorithm, which performs well, especially in higher dimensional space. An improved archive maintenance strategy has been introduced in this algorithm which is adaptive as well as dynamic in size. The archive maintenance strategy tries to maintain only the set of nondominated solutions in the archive. However, it maintains a minimum size of population when the nondominated solutions are not sufficient to fill the population. In this algorithm we have proposed a new environmental selection and a new mating selection. The mating selection reduces the exploration in less probable search region enhancing the exploitation of existing solutions. A new crossover operator DE-3 has also been proposed in this article. The proposed algorithm has been compared with three other existing multi-objective optimization algorithms NSGA-II, SPEA2 and AbYSS. Our algorithm outperforms the other three algorithms for its better diversity and convergence to true Pareto optimal front.

Visualization of Pareto Solutions applications optimization problems. Recently, Multi-Objective Genetic Algorithm, which is the application of Genetic Algorithm to Multi-objective Optimisation Problems, 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 visualisation method using an idea of Isomap proposed in the field of multiple classification analysis which visualises manifold embedded in the high dimensional space. The proposed method visualises the geometric distances of solutions in the design variable space considering their distances in the objective space. This method enables a user to analyse 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. We found interesting structure in the Pareto solutions by applying proposed method to this problem. It shows that the visualised result gives some knowledge on the features between design variables and fitness values in the acquired Pareto solutions.

Approach data mining this paper proposes two new filter feature selection methods for classification problems. The first algorithm is based on BPSO and the mutual information of each pair of features, which determines the relevance and redundancy of the selected feature subset. The second algorithm is based on BPSO and the entropy of each group of features, which evaluates the relevance and redundancy of the selected feature subset. Different weights for the relevance and redundancy in the fitness functions of the two proposed algorithms are used to further improve their performance in terms of the number of features and the classification accuracy. In the experiments, a decision tree (DT) is employed to evaluate the classification accuracy of the selected feature subset on the test sets of four datasets. The results show that with proper weights, two proposed algorithms can significantly reduce the number of features and achieve similar or even higher classification accuracy in almost all cases. The first algorithm usually selects a smaller feature subset while the second algorithm can achieve higher classification accuracy.

Hypercube Archive, Mutation and Population Competition algorithm (mPSO-DHA) with a dynamic hypercube archive (DHA), mutation and population competition is presented to enhance the performance of PSO in solving multi-objective optimisation problems. The proposed algorithm considers a modification of the hyper-cube archiving method originally proposed in 2002 by Coello and Lechuga, and changes the bounds of the objective space dynamically in the optimization process. When the particles are trapped in local Pareto fronts, the algorithm introduces a mutation process in order to help the particles jump out. Also, weight adaptation and pool selection techniques are introduced in order to enhance the local searching ability. The proposed algorithm is applied to a series of well-known benchmark problems, and results show that it can successfully find the true Pareto front with a good diversity of the solutions. In comparison to several other multi-objective particle swarm optimization algorithms, the proposed scheme showed better performance in solving benchmark functions.

Swarm Optimization Large-scale problems. evaporation in two variants of Particle Swarm Optimization

(PSO) on large-scale optimization problems. The variants in consideration are the Synchronous PSO (S-PSO) and the Random Asynchronous PSO (RA-PSO), both of which are evaluated upon the set of benchmark functions presented at the IEEE CEC'2010 Special Session and Competition on Large-Scale Global Optimisation. Results show a significant detriment to the performance of both variants in the presence of different levels of noise. However, such detriment is significantly mitigated by incorporating an evaporation mechanism into particles to deal with such disruptive effects. Moreover, results show that RA-PSO is significantly better than S-PSO, more tolerant to noise, and better suited for the evaporation mechanism.

search due to their ability to exploit gradients in the search landscape, formed by the algorithm's search operators in combination with the objective function. Research into the suitability of algorithmic approaches to problems has been made more tangible by the direct study and characterisation of the underlying fitness landscapes. Authors have devised metrics, such as the autocorrelation length, to help define these landscapes. In this work, we contribute the Predictive Diagnostic Optimisation method, a new local-search-based algorithm which provides knowledge about the search space while it searches for the global optimum of a problem. It is a contribution to a less researched area which may be named Diagnostic Optimisation.

quillotinable problems, and show its practical importance in solving the task of creating optimal cutting plans for a circular saw. Furthermore, we create a new algorithm suited for solving of semi-guillotinable problems by adapting existing evolutionary algorithms for both guillotinable and non-guillotinable 2D stock cutting problems. This algorithm is compared to standard algorithms on a selected set of both benchmark and real-life problems.

and selective pickups hyper-heuristics problem with deliveries and selective pickups (SVRPDSP). A vehicle departs loaded from the depot, visit every customer delivering a certain amount of goods according to their demand, and optionally pickup items from those customers, receiving a profit for each pickup realised. The vehicle has a limited capacity, which may turn impossible to attend all pickups, or make this unprofitable if it has to come back later in the customer after unloaded enough to fit the pickup demand. The objective is to find a minimal cost feasible route, the cost being the total travel costs minus the total revenue earned with pickups. Despite the many real applications, the literature is scarce. We propose an evolutionary algorithm whose crossover and mutation operators use data mining strategies to capture good characteristics from the parents and the population. Solutions are improved by a VNS algorithm during the process, and new solutions are introduced regularly to avoid premature convergence, using good constructive algorithms. The algorithm was tested with a benchmark of 68 instances, and the results compared to other publications. The results show the robustness of the method and 7 new solutions were found, including 2 new optimal solutions.

Intelligent Analysis of Incident Management Processes in a large number of domains. Also in the field of business process management, there exists an urgent need to beneficially use these data to retrieve actionable knowledge about the actual way of working in the context of a certain business process. The research field concerned is process mining, which can be defined as a whole family of analysis techniques for extracting knowledge from information system event logs. In this paper, we present a solution strategy to leverage traditional process discovery techniques in the flexible environment of incident management processes. In such environments, it is typically observed that single model discovery techniques are incapable of dealing with the large number of different types of execution traces. Accordingly, we propose a combination of trace clustering and text mining to enhance process discovery techniques with the purpose of retrieving more useful insights from process data.

quality dimensions (fitness, simplicity, generalisation, and precision) and may produce anomalous process models (e.g., deadlocking models). Therefore, we propose a new genetic process mining algorithm that discovers process models from event logs. The tree representation ensures the soundness of the model. Moreover, as experiments show, it is possible to balance the different quality dimensions. Our genetic process mining algorithm is the first algorithm where the search process can be guided by preferences of the user while ensuring correctness.

Programming and distributed algorithms time. But, many real-world problems are complex and have multitasks, and it is a bit hard to learn them well by one machine learning approach. So, the simultaneous learning of several tasks has been considered, that is, so-called multitask learning. This paper describes a new approach to the autonomous agent problem using the multitask learning scheme based on Genetic Network Programming (GNP), called ML-GNP, where each GNP is used to learn one corresponding task. MLGNP has some characteristics, such as distribution, interaction and autonomy,

which are helpful for learning multitask problems. The experimental results illustrate that ML-GNP can give much better performance than learning all the tasks of the problem by one GNP algorithm.

Approach are introduced and gene/locus pair as a Unique Inheritance if the pair satisfies one of the hypotheses is characterised in this paper. A method based on a statistical approach to extract a set of gene-locus pairs characterised as Unique Inheritance is proposed, and also two new genetic operations, attraction mutation and repulsion mutation are introduced. To confirm the effect, the proposal is applied to a genetic algorithm to solve the quadratic assignment problem. The results show that proposed two new mutations contributed to obtain more exact solutions in a shorter time than a traditional simple mutation.

Fisher's Runaway Process classic genetic algorithms(GAs), the evolutionary process is only implemented on an unisexual population. Although some sexual selection schemes for GAs have been proposed, only limited studies are focused on detailed mechanisms in sexual selection. In this paper, we focus on the modelling of some significant components in sexual selection, including the concepts of male trait, female mating preference. Thereafter, a novel evolutionary framework is constructed based on these models. The theoretical principle of this framework is the famous mechanism called Fisher's runaway process. Numeric optimization is carried out to evaluate the newly proposed framework on a large number of benchmark functions used in CEC2005 Special Session. Comparing with a classic real-coded genetic algorithm, the novel framework outperforms it on most functions. Although this framework is very preliminary, it has shown good potential in solving optimization problems.

important aspect for service-oriented systems. The selection based on QoS allows the user to include also non-functional attributes in their query, such as availability and reliability. Several exact methods have been proposed in the past, however, given that the workflow selection problem is NP-hard, approximate algorithms can be used to find suboptimal solutions for requested workflows. Genetic algorithm is one such method that can find approximate solutions in the form of services selected. In this paper, we propose an improved version of the standard genetic algorithm approach by making use of the clonal selection principle from artificial immune systems. Experimental results show that the clonal selection based genetic algorithm achieves much higher fitness values for the workflow selection problem than standard genetic algorithm.

Context metaheuristic, which describes bird flocking trajectories by a quantum behaviour. It uses only one tunable parameter and suggests a new and interesting philosophy for moving in the search space. It has been successfully applied to several problems. In this paper, we investigate the possibility of extending QPSO to handle multiple objectives. More specifically, we address the way global best solutions are recorded within an archive and used to compute the local attractor point of each particle. For this purpose, a two level selection strategy that uses sigma values and crowding distance information has been defined in order to select the suitable guide for each particle. The rational is to help convergence of each particle using sigma values while favouring less crowded regions in the objective space to attain a uniformly spread out Pareto front. The proposed approach has been assessed on test problems for function optimization from convergence and diversity points of view. Very competitive results have been achieved compared to some state of the art algorithms.

Design Problems computation, Engineering applications framework features auto-adaptive search that tailors itself to effectively explore different problem spaces. A key auto-adaptive feature of the Borg MOEA is the dynamic allocation of search across a suite of recombination and mutation operators. This study explores the application of the Borg MOEA on a real-world product family design problem: the severely constrained, ten objective General Aviation Aircraft (GAA) problem. The GAA problem represents a promising benchmark problem that strongly highlights the importance of using auto-adaptive search to discover how to exploit multiple recombination strategies cooperatively. The auto-adaptive behaviour of the Borg MOEA is rigorously compared against its ancestor algorithm, the Epsilon-MOEA, by employing global sensitivity analysis across each algorithm's feasible parameter ranges. This study provides the first Sobol' sensitivity analysis to determine the individual and interactive parameter sensitivities of MOEAs on a real-world many-objective problem.

Unbounded Archives in order to store the optimal points found so far during the optimization process. Usually the size of an archive is bounded which means that the number of points it can store is limited. This implies that knowledge about the set of non-dominated solutions that has been obtained during the optimization process gets lost. Working with unbounded archives allows to keep this knowledge which can be useful for the progress of an evolutionary multi-objective algorithm. In this paper, we propose an adaptive data structure for dealing with unbounded archives. This data

structure allows to traverse the archive efficiently and can also be used for sampling solutions from the archive which can be used for reproduction.

Yard Cranes to Reduce Fuel Consumption at Seaport Container Transshipment Terminals optimization, Engineering applications with weights (BRP-W) in which a set of identically-sized items of different, known weights are to be retrieved from a set of last-in-first-out (LIFO) stacks in a specific order using the minimum amount of energy. Our efforts to address this real-world problem resulted in the creation of a sophisticated algorithm–the global retrieval heuristic (GRH)–that decides where to relocate the items that must be moved to allow access to items below them. The GRH was embedded inside a genetic algorithm (GA)-based optimization method in a simulation-optimization structure in order to identify the best settings of the GRH for a particular item configuration size. Results from the preliminary experiments described here indicate that the GRH and GA have the potential to be effective tools to solve this very difficult problem.

DNA Count Data biomedical applications, Evolutionary simulation-based optimization data are divided in to different segments by an unknown number of change points. Each segment is supposed to be generated by unique distribution characteristics inherent to the underlying process. In this paper, we propose a modified version of the Cross-Entropy (CE) method, which uses beta distribution to simulate locations of change points. Several stopping criteria are also discussed. The proposed CE method applies on over-dispersed count data, in which the observations are distributed as independent negative binomial and the change points are simulated according to the beta distribution. Furthermore, we incorporate Bayesian Information Criterion (BIC) to identify the optimal number of change points within the CE method while not fixing the maximum number of change points in the data sequence. We obtain estimates for the artificial data by using the modified CE method and compare the results with the general CE method which uses normal distribution to simulate locations of the change points. The methods are applied to a real DNA count data set in order to illustrate the usefulness of the proposed modified CE method.

Packing Problem SPEA2 (Strength Pareto Evolutionary Algorithm 2) coupled, separately, with four placement heuristics for solving the 2D Guillotine Strip Packing Problem. In this study, the problem requires minimisation of both the amount of wasted material and the number of independent cuts required by a packing. With the goal of solving this multiobjective version of the problem, the construction phase of the GRASP algorithm (Greedy Randomised Adaptive Search Procedure) is used to generate a portion of the initial population of SPEA2. Four different placement heuristics, Next-Fit, a variation of Next-Fit, Best-Fit and First-Fit, were coupled with SPEA2 and were tested on a set of test data. The results show that the presented methodology is able to generate a good set of candidate solutions for each test problem. A statistical comparison methodology, based on multiobjective principles, was used to compare the four algorithm variants.

N- player Prisoner's Dilemma game via stigmergic interactions. Here, agent decision making is guided by a shared pheromone table. Actions are played at each time step and a trace (or signal) corresponding to the rewards received is recorded in this shared table. Subsequent actions are then determined probabilistically using the shared information. Comprehensive Monte Carlo simulation experiments show that the stigmergy-based mechanism is able to promote cooperation despite the fact that the make-up of the interacting groups is continually changing. A direct comparison with a genetic algorithm-based N-player model confirms that the extent of cooperative behaviour achieved is significantly higher across a wide range of cost-to-benefit ratios. In the concluding remarks, we highlight the real-world implications of stigmergic interactions.

behave in certain ways. Most commitments may depend on some incentive that is required to ensure that the action is in the agent's best interest and thus, should be carried out to avoid eventual penalties. Similarly, individuals may ground their decision on an accurate assessment of the intentions of others. Hence, both commitments and intention recognition go side by side in behavioural evolution. Here, we analyse the role played by the co-evolution of intention recognition plus the emergence of commitments, in the framework of the evolution of cooperative behaviour. We resort to tools of evolutionary game theory in finite populations, showing how the combination of these two aspects of human behaviour can enhance the emergent fraction of cooperative acts under a broad spectrum of configurations.

Framework for the Evolution of Multi Agent Systems through Bootstrapping Human Aesthetic Judgments computation social simulations and game artificial intelligence in order to incorporate the complexity and richness of action and interaction into the characters in the virtual environments while keeping computational cost low. This paper presents an approach to synthesise the spatio-temporal

dynamics of groups in standing conversation: four simple spatial rules form the building-blocks and a framework to automatically evolve rule and the parameter space by bootstrapping a-priori human judgement on the aesthetic quality of the simulations is introduced. The framework consists of a Genetic Algorithm and a scorer (fitness function) developed based on a machine learning system trained using human evaluations. The results of the study suggest that the framework is capable of deriving optimal rule and parameter combinations using only a relatively small set of human scored training data. Further, the relationship between rule-complexity and visual fidelity is explored.

environment having as primary goal to collect data. However, due to limited sensor communication range, oftentimes it is necessary to use a mobile node that will visit other nodes to gather up their collected data. This work addresses the problem of planning efficient paths for data collection by a mobile node model ed as a nonholonomic vehicle with curvature constraints. We propose an efficient algorithm to identify areas of intersection among the nodes RF footprints which will guide the identification of a smaller set of way points through which the vehicle needs to traverse in order to collect available data. Then, a metric similar to the classical Travelling Salesman Problem is used to determine the best circuit that includes all these collecting points. In order to reduce the total path length for the mobile node, a meta-heuristic is used. The classical Dubins' path technique is employed to generate a feasible tour for the vehicle and a new heuristic is used to generate the required orientation at the collecting points. The methodology was validated in a simulated environment. Our methodology outperforms the classical Alternating Algorithm and the best performing state-of-the-art algorithm.

performances of a robotics skill. The algorithm extends a previously proposed graphical evolutionary skills building approach to allow a robot to autonomously collect use cases where a skill fails and use them to improve the skill. Here we define a computational graph as a generic model to hierarchically represent skills and to modify them. The computational graph makes use of embedded neural networks to create generic skills. We tested our proposed algorithm on a real robot implementing a move to reach action. Four experiments show the evolution of the computational graph as it is adapted to solve increasingly complex problems.

software automata. In fact this method represents an indirect mapping between the input combinations of states in the cellular neighbourhood and the next states of the cells between the development steps. The objective of the program-based representation is to reduce the length of the chromosome in case of the evolutionary design of cellular automata. It will be shown that the instruction-based development allows us to design complex cellular automata with higher success rate than the conventional table-based method especially for complex cellular automata with more than two cell states. The case studies include the replication problem and the problem of development of a given pattern from an initial seed.

Index-based Neighborhoods are able to handle multimodal functions, have been recently proposed. The DE/nrand family incorporates information regarding the real nearest neighbourhood of each potential solution, which aids them to accurately locate and maintain many global optimisers simultaneously, without the need of additional parameters. However, these strategies have increased computational cost. To alleviate this problem, instead of computing the real nearest neighbour, we incorporate an index-based neighbourhood into the mutation strategies. The new mutation strategies are evaluated on eight well-known and widely used multimodal problems and their performance is compared against five state-of-the-art algorithms. Simulation results suggest that the proposed strategies are promising and exhibit competitive behaviour, since with a substantial lower computational cost they are able to locate and maintain many global optima throughout the evolution process.

numerical optimization problems. However, the performance of DE is sensitive to the choice of the mutation and crossover strategies and their associated control parameters. Therefore, to obtain optimal performance, time consuming parameter tuning is necessary. In DE, different mutation and crossover strategies with different parameter settings can be appropriate during different stages of the evolution. Therefore, to obtain optimal performance using DE, various adaptation and self-adaptation techniques have been proposed. Recently, a DE algorithm with an ensemble of parameters and strategies (EPSDE) was proposed. 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 degrades if the population members get struck with a combination of strategies and parameters values that produce successful offspring but lead to premature convergence in the due course of the evolution. In this paper, we try to improve the performance of the EPSDE algorithm with the help of a surrogate model that assists in generating competitive trial vectors corresponding to each parent in every generation of the evolution. The proposed algorithm is

referred to as surrogate model assisted EPSDE (SMA-EPSDE) and employs a simple Kriging model to construct the surrogate. The performance of EPSDE is evaluated on a set of 17 bound-constrained problems and is compared with state-of-the-art algorithms.

objective optimization problems. One major feature of this hybrid multi- objective differential evolution (HMODE) algorithm is that it adopts subpopulations whose sizes are dynamically adapted during the evolution process. The second feature is that the HMODE adopts a new solution update mechanism instead of the standard one used in the traditional differential evolution. The HMODE uses multiple operators and assigns an operator to each subpopulation. The update of each subpopulation is based on the assigned operator. The third feature of the HMODE is that a self-adapt local search method is used to improve the external archive. Computational study on benchmark problems shows that the HMODE is competitive or superior to previous multi-objective algorithms in the literature.

algorithms as GP are called as probabilistic model building GPs (PMBGPs), and they show better search performance than GP in many problems. A problem of prototype tree-based method, a type of PMBGPs, is that samplings do not always generate the most probable solution, which is the individual with the highest probability and reflects a learnt distribution most. This problem wastes a part of learning and increases the number of evaluations to get an optimum solution. In order to overcome this difficulty, this paper proposes a hybrid approach using Belief propagation (BP) in sampling process. BP is an inference algorithm on graphical models and can generate the most probable solution. By applying our approach to benchmark tests, we show that the proposed method is more effective than PLS alone.

Structures Using Reinforcement Learning algorithms, Adaptive dynamic programming and reinforcement learning, Representation and operators Probabilistic Model Building Genetic Network Programming (PMBGNP) has been proposed. Inspired by classical EDAs, PMBGNP memorises the current best individuals and uses them to estimate a distribution for the generation of the new population. However, PMBGNP can evolve compact programs by representing its solutions as graph structures. Therefore, it can solve a range of problems different from conventional ones in EDA literature, such as data mining and Reinforcement Learning (RL) problems. This paper extends PMBGNP from discrete to continuous search space, which is named PMBGNP-AC. Besides evolving the node connections to determine the optimal graph structures using conventional PMBGNP, Gaussian distribution is used for the distribution of continuous variables of nodes. The mean value mu and standard deviation sigma are constructed like those of classical continuous Population-based incremental learning (PBILc). However, a RL technique, i.e., Actor-Critic (AC), is designed to update the parameters (mu and sigma). AC allows us to calculate the Temporal-Difference (TD) error to evaluate whether the selection of the continuous value is better or worse than expected. This scalar reinforcement signal can decide whether the tendency to select this continuous value should be strengthened or weakened, allowing us to determine the shape of the probability density functions of the Gaussian distribution. The proposed algorithm is applied to a RL problem, i.e., autonomous robot control, where the robot's wheel speeds and sensor values are continuous. The experimental results show the superiority of PMBGNP-AC comparing with the conventional algorithms.

Continuous Estimation of Distribution Algorithms Statistical & Machine Learning Techniques dependencies between solution variables. A Gaussian distribution over continuous variables is commonly used, with several different covariance matrix structures ranging from diagonal i.e. Univariate Marginal Distribution Algorithm (UMDAc) to full i.e. Estimation of Multivariate Normal density Algorithm(EMNA). A diagonal covariance model is simple but is unable to directly represent covariances between problem variables. On the other hand, a full covariance model requires estimation of (some number) parameters from the selected population. In practice, numerical issues can arise with this estimation problem. In addition, the performance of the model has been shown to be sometimes undesirable. In this paper, a modified Gaussian-based continuous EDA is proposed, called sEDA, that provides a mechanism to control the amount of covariance parameters estimated within the Gaussian model. To achieve this, a simple variable screening technique from experimental design is adapted and combined with an idea inspired by the Pareto front in multi-objective optimization. Compared to EMNAglobal, the algorithm provides improved numerical stability and can use a smaller selected population. Experimental results are presented to evaluate and compare the performance of the algorithm to UMDAc and EMNAglobal.

Decomposition-based Frameworks of Multi-objective Optimization Evolutionary simulation-based optimization evolutionary algorithms have been designed. Each of the algorithms performs well in certain cases and none of them are dominating one another. This study is based on the idea of

synthesising different evolutionary algorithms so as to complement the limitations of each algorithm. On top of this idea, this paper proposes an adaptive mechanism that synthesises a genetic algorithm, differential evolution and estimation of distribution algorithm. The adaptive mechanism takes into account the ratio of the number of promising solutions generated from each optimiser in an early stage of evolutions so as to determine the proportion of the number of solutions to be produced by each optimiser in the next generation. Furthermore, the adaptive algorithm is also hybridised with the evolutionary gradient search to further enhance its search ability. The proposed hybrid adaptive algorithm is developed in the domination-based and decomposition-based multi-objective frameworks. An extensive experimental study is carried out to test the performances of the proposed algorithms in 38 state-of-the-art benchmark test instances.

Time-varying Number of Tasks Real-world applications etc.) that operates in a dynamic environment needs to be adaptive to changes; it should also anticipate possible adverse events to remain competitive. In our previous research in this area we experimented with one particular approach: Mapping of Task ID for Centroid-Based Adaptation with Random Immigrants (McBAR) to address problems of environmental changes for Resource-Constrained Project Scheduling (RCPS) problem, especially when the latter involves changes in task numbers. However, at that time, McBAR was applied as reactive tool only. In this paper we extend McBAR approach to the RCPS problem in a proactive-reactive way. The system handles also three competing objectives: cost, makespan, and the risk of failure. We have not found any papers that deal with risk on the RCPS problem and use the attributes of plans from the past environmental changes. This particular aspect is incorporated in McBAR, experimental results indicate the efficiency of such approach in finding optimal solutions for a current change. In this paper we also analyse, under the effects of environmental dynamics, the variation of risk computed via McBAR and of parameters related to optimization.

Interest Papers relies on decomposition strategies to convert a multi-objective problem into a set of single-objective problems. The use of a reference point allows the algorithm to focus the search on more preferred regions which can potentially save considerable amount of computational resources. The algorithm that we proposed, dynamically adapts the weight vectors and is able to converge close to the preferred regions. Combining decomposition strategies with reference point approaches paves the way for more effective optimization of many-objective problems. The use of a decomposition method alleviates the selection pressure problem associated with dominance-based approaches while a reference point allows a more focused search. The experimental results show that the proposed algorithm is capable of finding solutions close to the reference points specified by a decision maker. Moreover, our results show that high quality solutions can be obtained using less computational effort as compared to a state-of-the-art decomposition based evolutionary multi-objective algorithm.

data mining, Convergence, scalability and complexity analysis groups of similar points. Recent approaches for data clustering have seen the development of unsupervised learning algorithms based on Particle Swarm Optimization (PSO) techniques. These include Particle Swarm Clustering (PSC) and Modified PSC (mPSC) algorithms for solving clustering problems. However, the PSC and mPSC algorithms tend to be computationally expensive when applied to datasets that have higher levels of dimensionality and large volumes. This paper presents a novel and more efficient swarm clustering strategy we call Rapid Centroid Estimation (RCE). We compare the performance of RCE with the performance of PSC and mPSC in several ways including complexity analyses and particle behaviour analyses. Our benchmark testing suggests that RCE can reach a solution 274 times quicker than PSC and 270 times quicker than mPSC for a clustering task where the dataset has a dimension of 80 and a volume of 500. We also investigated particle behaviours on two-class two-dimensional datasets with volume of 500, presenting 250 data for each well-separated class with known Gaussian centers. We found that RCE converged to the appropriate centers at 70 updates on average, compared to 19802 updates for PSC and 23006 updates for mPSC. An ANOVA indicates RCE is significantly faster than both PSC and mPSC.

Interface (IEEE-CEC) computational power for distinguishing different classes. Dimension reduction is commonly used to reduces the necessary training time of the classifiers with some degree of accuracy lost. The dimension reduction is usually performed on either feature or electrode space. In this study, a new dimension reduction method that reduce the number of electrodes and features using variations of Particle Swarm Optimization (PSO) is used. The variation is in terms of parameter adjustment and adding a mutation operator to the PSO. The results are assessed based on the dimension reduction percentage, the potential of selected electrodes and the degree of performance lost. An Extreme

Learning Machine (ELM) is used as the primary classifier to evaluate the sets of electrodes and features selected by PSO. Two alternative classifiers such as Polynomial SVM and Perceptron are used for further evaluation of the reduced dimension data. The results indicate the potential of variations of PSO for reducing up to 99percent of the data with minimal performance lost.

Interface (IEEE-CEC) systems, with EA based Feature/ Electrode Reduction (FR/ER) methods showing significant potential for this purpose. A PSO based approach can reduce 99percent of the EEG data in this manner while demonstrating generalizability through the use of 3 new subsets of features/electrodes that are selected based on the best performing subset on the validation set, the best performing subset on the testing set, and the most commonly used features/electrodes in the swarm. This study is focused on applying the subsets generated from 4 subjects on a 5th one. Two schemes for this are implemented based on i) extracting separate subsets of feature/electrodes for each subject (out of 4 subjects) and combining the final products together for use with the 5th subject, and ii) concatenating the preprocessed EEG data of 4 subjects together and extracting the desired subset with PSO for use with the 5th subject. The results indicate the feasibility of generating subsets of feature/electrode indexes that are task specific and can be used on new subjects.

Scattered Data Classification, clustering, data analysis and data mining spaces plays an important role in optimization. A form of fitness landscape analysis is often carried out to describe the problem space in terms of modality, smoothness and variable separability. The outcomes of this analysis can then be used as a measure of problem difficulty and to predict the behaviour of a given algorithm. However, the metric value estimates of the landscape characterisation are dependent upon the representation scheme adopted and the sampling method used. Consequently, the development of a complete classification of problem structure and complexity has proved to be challenging. In this paper, we continue this line of research. We present a methodology for the characterisation of two dimensional numerical optimization problems. In our approach, data extracted during the search process is analysed and the dependency of the results to the nominated sampling method are corrected. We show via computational simulations that the calculated metric values using our approach are consistent with the results from random experiments. As such, this study provides a first step towards the on-line calculation of fitness landscape characterisation metrics and the development of empirical performance models of search algorithms. Advances in these areas would provide answers to the algorithm selection and portfolio configuration problems.

Multi-Objective Optimization applications models in multi-objective optimization: expected improvement (EI), expected hypervolume improvement (EHVI), estimation (EST), and those combination (EHVI+EST). EI has been conventionally used as the criterion considering the stochastic improvement of each objective function value individually, while EHVI has been recently proposed as the criterion considering the stochastic improvement of the front of non-dominated solutions in multi-objective optimization. EST is the value of each objective function, which is estimated non-stochastically by the Kriging model without considering its uncertainties. Numerical experiments were implemented in the welded beam design problem, and empirically showed that, in a non-constrained case, EHVI keeps a balance between accurate and wide search for non-dominated solutions on the Kriging models in multi-objective optimisation. In addition, the present experiments suggested future investigation into the techniques for handling uncertain constraints to enhance the capability of EHVI in a constrained case.

Approach applications optimization approach to optimise airfoil aerodynamic designs. Our approach makes use of multiple surrogate models which operate in parallel with the aim of combining their features when solving a costly multi-objective optimization problem. The proposed approach is used to solve five multiobjective airfoil aerodynamic optimization problems. We compare the performance of a multi-objective evolutionary algorithm with surrogates with respect to the same approach without using surrogates. Our preliminary results indicate that our proposal can achieve a substantial reduction in the number of objective function evaluations, which has obvious advantages for dealing with expensive objective functions such as those involved in aeronautical optimization problems.

Improved Evolutionary Multi-objective optimization Algorithm with Fuzzy-Dominance dynamic object group changing their positions with time. The information about the location of the object group is provided to the sensor manager. The manager invokes optimization algorithm whenever the obtained coverage falls below a threshold to sleep schedule the sensor network. Multi-objective Optimisation (MO) algorithms help in finding a better trade-off among energy consumption, lifetime, and coverage. Here the motion of the particle is modelled to follow a polynomial variation and with a constant acceleration. We formulate the scheduling problem as a combinatorial, constrained

and multi-objective optimization problem with energy and non-coverage as the two objectives to be minimised. The proposed scheme uses an improved variant of a powerful MO algorithm known as Decomposition based Multi-Objective Evolutionary Algorithm (MOEA/D). Systematic comparison with the original MOEA/D and another well-known MO algorithm, NSGA-II (Non-dominated Sorting Genetic Algorithm) quantifies the superiority of the proposed approach.

Proportional Distribution efficient population-based stochastic processing, has become an indispensable algorithm for solving numerical optimization problems widely. It is found in various benchmark functions that traditional MODE is unable to search global optima completely, falling into local optima because only using one strategy to search global optimal. This paper proposes adjustable proportional distribution (APD) mechanism to deal with this problem. The proposed APD-MODE can combine several strategies with proportional distribution to search global optima. It calculates proportions of each strategy in external archive and then uses Taguchi method to select the best proportion in evolution. In next iteration, it selects the best proportion to adjust particles size and scale factor F used in each strategy according to Taguchi method. Benchmark experiments prove that APD-MODE can improve the maximum spread of solutions in external archive and find global optima more effectively and completely.

which the cluster number is uncertainty. It uses IWO (Invasive Weed Optimisation) algorithm to optimise two fuzzy clustering objective function simultaneously, and a variable-length real-coded scheme has been adopted, the variable length weed encodes the cluster centers with variable numbers. In order to keep the diversity of the weeds, we introduce a new mechanism called feedback update mechanism to update the individuals which the corresponding number of cluster centers has been eliminated in one generation. Finally, the Silhouette index is used to select the best solution. The algorithm is used to cluster 15 artificial data sets and 4 real life data and shows good performance.

Gradients spatially-structured evolutionary algorithms (GBSSEAs). GBSSEAs complete the parapatric speciation concept in SSEAs by introducing local fitness through the introduction of an ideal phenotype at each location in space and introducing local competition to match these phenotypes. This paper explores the theoretical niching properties of GBSSEAs, and demonstrates that their niche allocation behaviour differs from traditional niching algorithms in that allocation of individuals depends of the relative location of optima in the fitness landscape. The paper concludes with an examination of the parameter sensitivity of GBSSEAs, demonstrates the robustness of these parameters in the context of global multimodal optimisation, and provides indications for good parameter values for searching for optima of varying fitness.

only offer the benefits of parallelisation but are also regarded as models with an extensively distinct behaviour. This study applies for the first time an Island Model to the optimization of short-ranged Morse clusters, combined with a hybrid steady-state evolutionary algorithm and a local optimization method. Different migration parameters are experimented and the resulting behaviours are extensively analysed. Results are compared to a state-of-the-art sequential approach, showing slight improvements. Differences in behaviour between the Island Model and the sequential approach are comprehensively discussed. This study shows that Island Models are a competitive parallel approach with promising results on cluster geometry optimization problems.

Algorithms Evolutionary Algorithms (EAs) has been recently proposed in the literature. The motivation is clear: the high clustering coefficient and low characteristic path length of such networks makes them suitable for fast local information dissemination, while at the same time preventing it from quickly spreading on the whole population, as it happens in panmictic populations. However, even though several papers addressed this issue so far, only a few of them are able to provide competitive results with other panmictic and/or decentralised population EAs with similar configurations. Therefore, we perform ax study in this work, both theoretically and empirically, on the most appropriate mechanisms to generate SW topologies for Genetic Algorithms (a family of EA). The algorithms are analysed in terms of efficiency and efficacy, and the best studied variant is validated versus other GAs using well known centralised and decentralised population structures, outperforming them.

Circuits to design synchronous sequential circuits and minimise the circuit complexity (the number of logic gates and wires used). Firstly, we use evolutionary algorithm (EA) to implement states simplification and obtain near-optimal state assignment, which requires few logic gates and wires. Then, EHW evolves a set of high performing circuits and uses data mining method to find frequently evolved blocks (a component of logic gates) from these circuits in its pre-evolution stage. Frequently evolved blocks would be re-used in functional and terminals set for evolving better circuits. EHW has

a faster convergence so that the circuit with small complexity could be evolved. Auto starting ability of circuits would also be test by the fitness function of EHW. Finally, two sequence detectors, two module counters, and ISCAS'89 circuit are used as the proof for our evolutionary design approach. Simulation results of experiments are given, and our evolutionary algorithm is shown to be better than other methods in terms of convergence time, success rate, and maximum fitness across generations.

variety of problems. However, the successes have largely been with programs without iteration or recursion; evolving recursive programs has turned out to be particularly challenging. The main obstacle to evolving recursive programs seems to be that they are particularly fragile to the application of search operators: a small change in a correct recursive program generally produces a completely wrong program. In this paper, we present a simple and general method that allows us to pass back and forth from a recursive program to an equivalent non-recursive program. Finding a recursive program can then be reduced to evolving non-recursive programs followed by converting the optimum non-recursive program found to the equivalent recursive program. This avoids the fragility problem above, as evolution does not search the space of recursive programs. We present promising experimental results on a test-bed of recursive problems.

has the construction of new variables been left to the evolutionary process of a tree-based Genetic Programming system. We present a series of modifications to an existing GP approach to allow the evolution of high-level imperative programs with limited scope variables. We make use of several new program constructs made possible by the modifications and experimentally compare their use. Our results suggest the impact of variable declarations is problem dependent, but can potentially improve performance. It is proposed that the use of variable declarations can reduce the degree of insight required into potential solutions.

Local Search Algorithm for the Permutation Flowshop iterated local search (ILS) algorithm for the permutation flowshop problem with the objective of minimising total flow time. An ILS algorithm is applied to a set of test problems, and in each separate trial the algorithm is started from an initial solution generated by one of six different methods. Experimental results indicate that initial solutions generated by a neural network are more effective in promoting the performance of the ILS algorithm towards better solutions. A modified version of the ILS algorithm, in which an initially restricted neighbourhood search is gradually expanded with each iteration, is also proposed and tested. The results from this modified ILS compare very favourably with published results from a traditional ILS approach.

a graph such that the maximal number of cuts of a line separating consecutive vertices is minimised. CMP has significant applications in VLSI design, network communications, automatic graph drawings and information retrieval but it is proved to be a NP hard problem. Exact results of cutwidth are known for some classes of graphs but no algorithm has been proposed for the general graphs. In this paper, we present a hybrid evolutionary algorithm (HEA) for CMP which uses the depth first search of graph to generate the initial population and incorporates the simulated annealing in the selection process. HEA achieves the known optimal cutwidth of all the standard graphs tested. We also conjecture the cut width of some circulant graphs and generalised Peterson graphs supported by our experimental results.

have been modelled for the numerical optimization, but the local cooperation has not been modelled separately in optimization problems. In this paper the local cooperation is newly modelled as Neighbourhood Field Model (NFM). Based on NFM, a new optimization technique called Neighbourhood Field Optimisation algorithm (NFO) is firstly proposed to deliver global optimization. In NFO, each individual is attracted by its superior neighbour and repulsed by its inferior neighbour to search a better solution. In this paper, NFO is compared with certain algorithms under twelve different benchmark functions. The results show that NFO can outperform them on multimodal functions in the respect of accuracy, effectiveness and robustness. It also can be noted that the cooperation behaviour can play a dominant role in the optimization algorithm separately.

Applications to Image Search search spaces that are defined extensionally, i.e. by listing every item in the space. When these spaces are with a function that returns similar elements given a key element, analogies of mutation and crossover can be defined. This idea is discussed in general, and specific examples are given where the search is for images, in particular where image search is carried out using an interactive genetic algorithm.

especially in frameworks like industrial design, decision making and visual analytics. Interactive Evolution, used not only as an optimisation tool, but also as an exploration tool may provide some

versatile solutions to this challenge. This paper presents an attempt in this direction with the EvoGraphDice prototype, developed on top of GraphDice, a general purpose visualisation freeware for multidimensional visualisation based on scatter plot matrices. EvoGraphDice interactively evolves compound additional dimensions, that provide new viewpoints on a multidimensional dataset. Compound dimensions are linear combination of terms based on the initial data dimensions, they are initialised with a Principal Component Analysis (PCA), and modified progressively by the interactive evolution process. Various interactions are available to the user, either in a transparent way, via a capture of mouse-clicks, or in a fully controlled manner, where the user has the opportunity to modify or include his own compound dimension in the evolved population, control the search space, or do some interactive queries. EvoGraphDice is tested on a synthetic dataset of dimension 6, where a known dependency is rediscovered via interactive manipulation. A second example is presented, based on a real dataset of dimension 13, provided by an industrial partner. Our experiments prove the potential of this interactive approach, and allow us to sketch future directions of development for the EvoGraphDice prototype.

Maker Preference handling. problems, it is proposed to progressively integrate the decision maker with the execution of an evolutionary multi-objective optimization algorithm. Preferences from the decision maker are accepted at the intermediate steps of the algorithm and a progress towards the most preferred point is made. In this paper, we extend the work on 'progressively interactive evolutionary multi-objective optimization using value function' (PI-EMO-VF) by allowing the optimization to be performed in a fixed number of interactions with the decision maker. In the PI-EMO-VF procedure, information is accepted from the decision maker, which is used by the evolutionary algorithm to perform a focused search in the region of interest. However, it is not possible to restrict the number of interactions required to handle an optimization problem. This paper contributes towards, solving the optimization problem in a pre-decided number of decision maker calls. Once the available budget of decision maker calls are known, it is optimally used to get close to the most preferred point on the Pareto-frontier. The paper evaluates the performance of the modified PI-EMO-VF algorithm on two, three and five objective test problems. A comparative study is performed against the previous proposal for the PI-EMO-VF procedure.

Workflows on Public Clouds Evolutionary simulation-based optimization private clouds, the allocation of workflow tasks to specific cloud instances to reduce run time and cost has emerged as an important challenge. The allocation of scientific workflows on public clouds can be described through a variety of perspectives and parameters and has been proved to be NP-complete. This paper presents an optimization framework for task allocation on public clouds. We present a solution that considers important parameters such as workflow run time, communication overhead, and overall execution cost. Our multi-objective optimization framework builds on a simple and extensible cost model and uses a heuristic to determine the optimal number of cloud instances to be used. Using the Amazon Elastic Compute Cloud (EC2) and Amazon Simple Storage Service (S3) as an example, we show how our optimization heuristics lead to significantly better strategies than other state-of-the-art approaches. Specifically, our single-objective optimisation is slightly better than a simple heuristic and a particle swarm optimization approach for small workflows, and achieves significant improvements for larger workflows. In a similar manner, our multi-objective optimization obtains similar results to our single-objective optimization for small-size workflows, and achieves up to 80percent improvement for large-size workflows.

Algorithms Optimization, Multiobjective optimization Algorithms (MOEAs) to solve the radar phase coded waveform design problem. The MOEAs are used to generate a series of radar waveform phase codes that have excellent range resolution and Doppler resolution capabilities while maintaining excellent autocorrelation properties. The study compares the ability of NSGA-II, SPEA2, and MOEA/D to generate a Pareto front of phase code solutions and then improve upon the quality of the solutions while maintaining a sufficient diversity of available radar phase codes. Results demonstrate that for solving moderate to large instances of the radar phase code problem all three MOEAs generate a diverse set of Pareto optimal radar phase codes. The phase codes generated by NSGA-II have overall better autocorrelation properties than those generated by SPEA2 and MOEA/D, however, all three MOEAs produce usable phase codes.

with Preference-based Selection Computation, Preference handling. individuals, which are updated using rotation gate by referring to nondominated solutions in an archive. In this way, a population can quickly converge to the Pareto optimal solution set. To obtain the specific solutions based on user's preference in the population, MQEA with preference-based selection (MQEA-PS) is developed. In this

paper, an improved version of MQEA-PS, MQEA-PS2, is proposed, where global population is sorted and divided into groups, upper half of individuals in each group are selected by global evaluation, and selected solutions are globally migrated. The global evaluation of nondominated solutions is performed by the fuzzy integral of partial evaluation with respect to the fuzzy measures, where the partial evaluation value is obtained from a normalised objective function value. To demonstrate the effectiveness of the proposed MQEA-PS2, comparisons with MQEA and MQEA-PS are carried out for DTLZ functions.

Track Cycling optimization applications, however currently generalised algorithms tend to be focused upon solving problems in a theoretical domain. We aim to develop a range of generalised algorithms more suited than current algorithms to practical applications. We contextualise our algorithms using the elite sport of Team Pursuit Track Cycling, which features as part of the Summer Olympics. The sport is fiercely competitive and fractions of a second often separate the world's leading teams. We set about using Evolutionary Computation to optimise strategies for elite teams of cyclists through changes in the transition timings and the riders power outputs. We trial our range of Evolutionary Computation methods, comparing various algorithms and running them within a time frame suitable for use in a real world environment. We find significantly better results are able to be obtained through our methods than current strategies being developed at an elite level and find the use of the developed algorithms favourable for use in a practical environment.

Optimization bilevel optimization. The test-collection represents various difficulties which are commonly encountered in practical bilevel optimization problems. To support experiments with problems of different size, all of the test problems are scalable in terms of the number of variables. The problem set is also accompanied by a construction procedure, which helps to generate new test problems with controlled difficulties in convergence and interaction patterns between the two optimization levels. To provide a baseline result for easy comparisons, we have solved a 10 variable instance for each of the test problems using a simple bilevel evolutionary algorithm. The results presented may be used as a benchmark while evaluating the performance of any bilevel optimization algorithm.

Model Multiobjective optimization, Real-world applications and people is the determination of number and type of platforms which will be needed. Due to the presence of multiple conflicting objectives, such as cost and performance, this problem may be considered multi-objective. In order to estimate the fleet that can fulfil the scenario requirements, the Stochastic Fleet Estimation Robust (SaFER) model was previously developed. It uses scheduling heuristics and optimization. However, using the SaFER model within a multi-objective optimization framework is not computationally feasible; therefore, a surrogate model is proposed in this paper to approximate SaFER for use in the fitness evaluations of schedule cost objectives. An artificial military air mobility dataset is used to demonstrate the increase in speed of the surrogate model over SaFER, and the accuracy of the surrogate model in estimating schedule costs versus SaFER.

Phylogenetic Tree Search algorithms biological species. Although parallel computation is essential for the phylogenetic tree searches, it is not easy to maintain the diversity of population in a parallel genetic algorithm. In this paper, we design a new asynchronous parallel genetic algorithm for tree optimization which maintain the diversity of population without any communication or synchronisation.

Genetic Algorithm data analysis and data mining and more significant among software users and providers. To offer a SaaS with flexible functions at a low cost, SaaS providers have focused on the decomposition of the SaaS functionalities, or known as composite SaaS. This approach has introduced new challenges in SaaS resource management in data centres. One of the challenges is managing the resources allocated to the composite SaaS. Due to the dynamic environment of a Cloud data centre, resources that have been initially allocated to SaaS components may be overloaded or wasted. As such, reconfiguration for the components' placement is triggered to maintain the performance of the composite SaaS. However, existing approaches often ignore the communication or dependencies between SaaS components in their implementation. In a composite SaaS, it is important to include these elements, as they will directly affect the performance of the SaaS. This paper will propose a Grouping Genetic Algorithm (GGA) for multiple composite SaaS application component clustering in Cloud computing that will address this gap. To the best of our knowledge, this is the first attempt to handle multiple composite SaaS reconfiguration placement in a dynamic Cloud environment. The experimental results demonstrate the feasibility and the scalability of the GGA.

Fitness Function Applications, Classification, clustering, data analysis and data mining interest in sociology, biology and computer science. Complex networks in nature and society range from the

immune system and the brain to social, communication and transport networks. The key issue in the development of algorithms able to automatically detect communities in complex networks refers to a meaningful quality evaluation of a certain community structure. Given a certain grouping of nodes into communities, a good measure is needed to evaluate the quality of the community structure based on the definition that a strong community has dense intra-connections and sparse outside community links. We propose a new fitness function for the assessment of community structures quality which is based on the number of nodes and their links inside a community versus the community size further reported to the size of the network. A novel aspect of the proposed fitness function refers to considering the way nodes connect to other nodes inside the same community making this second level of links contribute to the strength of the community. The introduced fitness function is tested inside a collaborative evolutionary algorithm specifically designed for the problem of community detection in complex networks. Computational experiments are performed for several real-world complex networks which have a known real community structure. This allows the direct verification of the quality of evolved communities via the proposed fitness function emphasising extremely promising numerical results.

Programming: The Effects of Recursive Structure algorithms, Evolutionary computation theory to Genetic Programming has adopted a Stochastic Context Free Grammar(SCFG)-based model formalism. However these methods generate biases which may be indistinguishable from selection bias, resulting in sub-optimal performance. The primary factor generating this bias is the combined effect of recursion in the grammars and depth limitation removing some sample trees from the distribution. Here, we demonstrate the bias and provide exact estimates of its scale (assuming infinite populations and simple recursions). We define a quantity h which determines both whether bias occurs ($h > 1$) and its scale. We apply this analysis to a number of simple illustrative grammars, and to a range of practically-used GP grammars, showing that this bias is both real and important.

Representation and operators Evolution, and examines approaches that can be used to minimise them. It analyses the traditional approach of reusing the same genetic material, known as wrapping, and shows why this is inefficient with some grammars used in the literature. It suggests the appending of non-coding genetic material to genotype strings, at the start of the run, and shows the benefits of this approach: higher probability of creating terminated individuals, better or similar experimental performance, and a tendency to generate smaller solutions, when compared to the use of wrapping.

Discrete and combinatorial optimization. promising crossover operators that perform multi-step neighbourhood search between parents, and applicable to various problems by introducing a problem-specific neighbourhood structure and a distance measure. Under their appropriate definitions, MSXF and dMSXF can successively generate offspring that acquire parents' good characteristics along the path connecting the parents. In this paper, we introduce MSXF and dMSXF to genetic programming (GP), and apply them to symbolic regression problem. To optimise trees, we define a neighbourhood structure and its corresponding distance measure based on the largest common subtree between parents with considering ordered/unordered tree structures. Experiments using symbolic regression problem instances showed the effectiveness of a GP with the proposed MSXF and dMSXF.

algorithms, Particle swarm optimization standard swarm. The use of diverse sub-swarms increases performance when optimising multi-modal functions. However, new design decisions arise when implementing multi-swarm systems such as how to select the initial positions and initial velocities, and how to coordinate the different sub-swarms. Starting from the relatively simple multi-swarm system of locust swarms, ideas from differential evolution and estimation of distribution algorithms are used to address the new design considerations that are specific to multi-swarm systems. Experiments show that the new hybrid system can perform better than each of the individual components.

parametrisation which has a significant influence on the algorithm's performance. In most cases, practitioners assign static values to variables after an initial tuning phase. This parameter tuning method requires experience the practitioner may not have and, when done conscientiously, is rather time-consuming. Also, the use of parameter values that remain constant over the optimisation process has been observed to achieve suboptimal results. This work presents a parameter control method which redefines variables repeatedly based on a separate optimisation process which receives its feedback from the primary optimisation algorithm. The feedback is used for a projection of the value performing well in the future. The parameter values are sampled from intervals which are adapted dynamically, a method which has proved particularly effective and outperforms all existing adaptive parameter controls significantly.

single objective optimization is proposed. In the novel algorithm, the population is divided into sub-groups with different parameters setting to balance the global and local search ability. The good information collected in the search process is exchanged among groups. Experiments are conducted on seven commonly used benchmark functions and two new constructed harder test functions which are useful to test the local search ability of the algorithms and the proposed algorithm shows its effectiveness and efficiency.

re-used features, is an important area of study in object recognition and classification, and relates to processes in the human visual system. Established techniques are able to build deep hierarchies using neural networks, such as deep learning based on Restricted Boltzmann Machines, however approaches using other machine learning techniques involving reinforcement are not well established. An approach is presented that uses a form of Learning Classifier System to build a hierarchical feature network, for classification of images using the MNIST dataset. Larger scale representations of rules are composed of re-used smaller elements, in a network of 4,000 features and 2,000 rules. The feature network is developed autonomously, according to reinforcement of rules the features participate in. An implementation is shown using the ARCS classifier system to perform classification of images, using rules based on image templates. A second implementation uses rules with image templates constructed from a hierarchical feature network. This shows effective classification performance, but not as accurate as the best neural network and kernel methods. The implementation shows the ability to construct a hierarchical feature network under reinforcement, and its application to develop a rule population used by a Learning Classifier System. An alternative method for modifying existing rules is shown to substitute for standard mutation and crossover processes, to allow exploration of the rule space more closely related to gradient descent and cognitively related processes, rather than the genetic analogy commonly used in learning classifier systems.

and Mapping for Autonomous Robotics complex problems of navigating: where it is, where it is going and how it is going to get there. The first is addressed by techniques for simultaneous localisation and mapping (SLAM). The next stage of navigating is to plan a path to a goal, which is often achieved by learning techniques due to the scale of search required. Commonly, the localisation and mapping stage is separated from path planning stage, with the function not of interest being considered ideal in order to simplify the problem (similarly, the goal is often predetermined by an external agent, such as a human operator specifying a location to reach). This work integrates the planning with the localisation and mapping in order to investigate the benefits of considering these aspects together (rather than as a separate functions as is often assumed). Firstly, experiments on real-robots show decreased localisation error in this approach (1.8 mm +/-0.41 mm to 1.2 mm +/-0.26 mm). Secondly, the number of steps to goal has concurrently been reduced (13.4 steps to 11.8 steps). This work is novel in the integration of evolutionary computation planning techniques with SLAM. It also has enabled the opportunity for rule-sharing between heterogeneous robots and the inclusion of action policies in SLAM filter updates.

Learning Automata optimization. Algorithms for solving numerical optimization problems. They are population based search heuristics that integrate the benefits of natural and cultural evolution. In this paper, we propose an Adaptive Memetic Algorithm, named LA-DE which employs a competitive variant of Differential Evolution for global search and Learning Automata as the local search technique. During evolution Stochastic Automata Learning helps to balance the exploration and exploitation capabilities of DE resulting in local refinement. The proposed algorithm has been evaluated on a test-suite of 25 benchmark functions provided by CEC 2005 special session on real parameter optimization. Experimental results indicate that LA-DE outperforms several existing DE variants in terms of solution quality.

computation, Evolutionary programming that combine the composite benefits of natural and cultural evolution. In this paper a synergism of the classical Differential Evolution algorithm and Q-learning is used to construct the memetic algorithm. Computer simulation with standard benchmark functions reveals that the proposed memetic algorithm outperforms three distinct Differential Evolution algorithms.

Real-world applications particular interest are enzymes, which process information in highly complex dynamic environments. Exploring the information processing characteristics of an enzyme by selectively altering its environment may lead to the discovery of new modes of computation. The physical experiments required to perform such exploration are combinatorial in nature. Thus resource consumption, both time and money, poses major limiting factors on any exploratory work. New tools are required to mitigate these factors. One such tool is lab-on-chip based autonomous experimentation system, where a microfluidic experimentation platform is driven by machine learning algorithms. The lab-on-chip

approach provides an automated platform that can perform complex protocols, which is also capable of reducing the resource cost of experimentation. The machine learning algorithms provide intelligent experiment selection that reduces the number of experiments required for discovery. Here we discuss development of the experimentation platform and machine learning software that will lead to fully autonomous characterisation of enzymes.

applications, Classification, clustering, data analysis and data mining approach. Its holistic approach is drastically different from the western medicine (WM). Upon the gathering of various symptoms in the diagnosis, a TCM practitioner prescribes treatment methods, of which herbal medicine is still one of the most popular. Each formula consists of multiple herbs. Since it is not a one-to-one mapping between symptom and herb, overlapping subsets of herbs are meant to address sets of overlapping symptoms. As a result, the discovery of the symptoms-herbs relationship is a crucial step to the research of the underlying TCM principle. The discovery of many existing formulae took a long time to stabilise to the current configurations. In this paper, the relationship discovery is argued to be more than just an evolutionary process, but a co-evolutionary process, i.e. a set of symptoms searches for candidate sets of herbs, while a given set of herbs are appropriate for multiple sets of symptoms. In other words, a well recognised symptoms-herbs relationship is the result of a dynamic equilibrium of two inter-related evolutionary processes. This model of discovery was implemented using a Combined Gene Genetic Algorithm (CoGA1) where the symptoms and herbs are encoded in the same chromosome to evolve over time. The algorithm was tested with an insomnia dataset from a TCM hospital. The algorithm was able to find the symptoms-herbs relationships that are consistent with TCM principles and have better fitness from Simple GA.

learning with applications to genome-wide association studies distribution algorithms variables for a regression or classification model such that the resulting model is best according to some criterion. Here we consider the use of population-based incremental learning (PBIL) to select the variables for a linear regression model to predict a quantitative trait in living organisms. The data here is simulated to represent a genome-wide association study (GWAS) using single nucleotide polymorphisms (SNPs) as explanatory variables and height as an example trait. PBIL was effective in optimising a variety of model fitness criteria. The resulting models were found to have true positive and false negative rates comparable to those of competing methods.

Compiler Flag Selection as a Seed Example computer codes of various nature poses a discreet challenge to the programmers in forms of code optimization. Programmers need to contemplate on optimization during pre and post implementation to take advantage of the hardware given for a specific nature of the code. To compliment this requirement, the evolution of compiler technology has resulted in built in optimization functionality called compiler flags. Like a switch the flag turns on or off for a particular optimization behaviour. The existence of various flags in turn causes confusion as to which flag or combination of flags to be used since misuse has detrimental effect on performance. In this work we are performing a comparative study on the use of Genetic Algorithm and Simulated Annealing in finding the best compiler flag combination respectively and finally proposing a hybrid algorithm that produces better flag combination in comparison to the former two.

Prescreening Method for Gaussian Process Surrogate Model Assisted Evolutionary Algorithms and Its Application attention for the solution of optimization problems with computationally expensive function evaluations. For small scale problems, the use of a Gaussian Process surrogate model and prescreening methods has proved to be effective. However, each commonly used prescreening method is only suitable for some types of problems, and the proper prescreening method for an unknown problem cannot be stated beforehand. In this paper, the four existing prescreening methods are analysed and a new method, called self-adaptive lower confidence bound (ALCB), is proposed. The extent of rewarding the prediction uncertainty is adjusted on line based on the density of samples in a local area and the function properties. The exploration and exploitation ability of prescreening can thus be better balanced. Experimental results on benchmark problems show that ALCB has two main advantages: (1) it is more general for different problem landscapes than any of the four existing prescreening methods; (2) it typically can achieve the best result among all available prescreening methods.

Criterions Surrogate-Assisted Evolutionary Optimisation of Expensive Problems, Meta-modelling and surrogate models engineering design to reduce the number of computational expensive simulations. However, real-world problems often consist of multiple, conflicting objectives leading to a set of equivalent solutions (the Pareto front). The objectives are often aggregated into a single cost function to reduce the computational cost, though a better approach is to use multiobjective optimization

methods to directly identify a set of Pareto-optimal solutions, which can be used by the designer to make more efficient design decisions (instead of making those decisions upfront). Most of the work in multiobjective optimization is focused on MultiObjective Evolutionary Algorithms (MOEAs). While MOEAs are well-suited to handle large, intractable design spaces, they typically require thousands of expensive simulations, which is prohibitively expensive for the problems under study. Therefore, the use of surrogate models in multiobjective optimization, denoted as MultiObjective Surrogate-Based Optimization (MOSBO), may prove to be even more worthwhile than SBO methods to expedite the optimization process. In this paper, the authors propose the Efficient Multiobjective Optimisation (EMO) algorithm which uses Kriging models and multiobjective versions of the expected improvement and probability of improvement criteria to identify the Pareto front with a minimal number of expensive simulations. The EMO algorithm is applied on multiple standard benchmark problems and compared against the well-known NSGA-II and SPEA2 multiobjective optimization methods with promising results.

with Multi-Objective Evolutionary Algorithms predict the market trends. The main difficulty in the use of TIs lies in deciding which are their optimal parameter values in each moment, since constant optima values do not seem to exist. In this work, the use of Multi- Objective Evolutionary Algorithms (MOEAs) is proposed to obtain the best values of the parameters in order to help to buy and sell shares. Those parameters are applied in real time and belong to a collection of indicators. Unlike other previous approaches, the necessity of repeating the parameter optimization process each time a new data enters the system is justified, searching for the best adjustment of the parameters (and hence the TIs) in every moment. The Moving Averages Convergence-Divergence (MACD) indicator and the Relative Strength Index (RSI) oscillator have been chosen as TIs, so the MOEAs will provide the best parameters to use them on investment decisions. Experiments compare up to nine different configurations with the Buy and Hold strategy (B and H). The obtained results show that the Multi-Objective technique proposed here can greatly improve the results of the B and H strategy even operating daily. This statement is also demonstrated by comparing the results to those previously presented in the literature.

crossover computation operators that introduce selective pressure on the recombination stage are proposed. Operators probabilistic rates based approach to GP self-configuration is suggested. Proposed modifications usefulness is demonstrated on benchmark test and real world problems.

analysis and data mining occurrences of user-interest in one or more time lines, such as finding an anomaly in electrocardiograms or reporting a sudden variation of voltage in a power supply. Current methods are not adequate for detecting certain kinds of events without any domain knowledge. Therefore, we propose a Genetic Programming (GP) based event detection methodology in which solutions can be built from raw time series data. The framework is applied to five synthetic data sets and one real world application. The experimental results show that working on raw data even with a dimensionality as high as 140 by 80, genetic programming can achieve superior performance to conventional methods operating on pre-defined features. Furthermore, analysis of the evolved event detectors shows that they can be readily understood by humans and have captured the regularities inserted into the synthetic data sets.

with Semantic Based Crossover Communications and Networking (IEEE-CEC), Real-world applications communications, where the noise is often characterised by the Gaussian distribution. However, no simple exact closed form of the Q-function is known. Consequently, a number of approximations have been proposed over the past several decades. In this paper, we use Genetic Programming with semantic based crossover to approximate the Q-function in two forms: the free and the exponential forms. Using this form, we found approximations in both forms that are more accurate than all previous approximations designed by human experts.

with Power of Two Policy hybrid algorithms algorithms to solve the economic lot scheduling problem (ELSP) under the extended basic period (EBP) approach and power-of-two (PoT) policy. In particular, DHS algorithms generate a cyclic production schedule, consisting of n items to be produced on a single machine, where the production cycle of each item is an integer multiple of a fundamental cycle. All the integer multipliers take the form of PoT which restricts the search space but provides good solution qualities. Under the EBP approach, feasibility is guaranteed with a constraint checking whether or not the items assigned in each period can be produced within the length of the period. For this restricted problem, which is still NP-hard, the proposed DHS algorithms employ 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 neighbourhood search (VNS) algorithm is also hybridised with DHS algorithms to further enhance the solution quality. The experimental results show that the proposed algorithms are very competitive to the best performing algorithms from the existing literature under the EBP and PoT policy

ROBDDs hybrid algorithms, Parallel and distributed algorithms order in Reduced Ordered Binary Decision Diagrams. The evolution process is inspired by a basic genetic algorithm. The population evolves on a bidimensional grid and is implicitly organised in geographical clusters that present a form of structural similarity between individuals. Two feature functions are used to measure the similarity between chromosomes. The approach considers multiple parallel evolving grids. A similarity based communication protocol between clusters of individuals from parallel grids is defined. The exchange of genetic material proves to considerably boost the quality of the solution. The extensive experimental evaluation uses difficult classical benchmarks and proves the efficiency and the stability of the algorithm. The approach systematically produces better results than the used basic genetic algorithm and better or similar results with other heuristic methods.

ability to balance exploration with exploitation. Exploration is required to find the best region, and exploitation is required to find the best solution (i.e. the local optimum) within this region. Compared to hill climbing which is purely exploitative, simulated annealing probabilistically allows backward steps which facilitate exploration. However, the balance between exploration and exploitation in simulated annealing is biased towards exploitation, improving moves are always accepted, so local (greedy) search steps can occur at even the earliest stages of the search process. The purpose of threshold convergence is to have these early-stage local search steps held back by a threshold function. It is suggested that early local search steps can interfere with the effectiveness of a search technique's (concurrent) mechanisms for global search. Experiments show that the addition of threshold convergence to simulated annealing can lead to significant performance improvements in multi-modal search spaces.

evolutionary computation inspired by human creative problem solving process. Human being is the most intelligent organism in the world and the brainstorming process popularly used by them has been demonstrated to be a significant and promising way to create great ideas for problem solving. BSO transplants the brainstorming process in human being into optimization algorithm design and gains successes. BSO generally uses the grouping, replacing, and creating operators to produce ideas as many as possible to approach the problem global optimum generation by generation. In this paper, we propose two novel designs to enhance the conventional BSO performance. The first design of the modified BSO (MBSO) is that it uses a simple grouping method (SGM) in the grouping operator instead of the clustering method to reduce the algorithm computational burden. The second design is that MBSO uses a novel idea difference strategy (IDS) in the creating operator instead of the Gaussian random strategy. The IDS not only contains open minded element to avoid the ideas being trapped by local optima, but also can match the search environment to create better new ideas for problem solving. Experiments have been conducted to illustrate the effectiveness and efficiency of the MBSO algorithm. Moreover, the contributions of SGM and IDS are investigated to show how and why MBSO can perform better than BSO.

High Risk Jobs simulation-based optimization, occupational health, brick, manufacturing, evolutionary multiobjective optimization, artificial neural network, risk assessment score earnings by subjecting themselves to greater risk of occupational health hazards (RoOHH) mainly due to economic reasons. To embark upon this issue, we introduce an intelligent system employing artificial neural network (ANN) and non-dominated sorting genetic algorithm (NSGA-II). Experiments are carried out in a brick manufacturing unit in India. Observations spell out that firing is the most severe job among others. A job-combination approach is incorporated wherein firing workers do another job along with firing to reduce their exposure to high temperature zone while maintaining their earnings to a satisfactory level. RoOHH is measured in terms of risk assessment score (RAS). ANN models the psychological responses of workers in terms of RAS, and facilitates the evaluation of one of the fitness function of NSGA-II. NSGA-II searches for optimal work schedules in a job-combination to minimise RAS and maximise earnings simultaneously.

are capable of running perpetually. When deployed as optimization tools, it is imperative to prescribe a set of definitive stopping criteria that if satisfied, the evolutionary process could be brought to a halt. User specified limits on maximum evaluations or generations are the common measures used to stop the evolution due to resource constraints that might directly/indirectly be imposed on the system. Conversely, we propose a novel convergence detection mechanism that monitors the contribution of

the genetic operators on the fitness progress and the diversity profile of the population via the one-standard deviation crossover envelope. This adaptively terminates the evolution as convergence sets in. Extended Price's theorem is used to estimate the dynamical contributions of the individual genetic operators. Experimental results show that under standard parameter settings with binary tournament selection, the proposed technique is robust and could be a promising alternative to the conventional similarity measure-based methods for convergence detection.

Parameter Learning of Neural Networks artificial neural networks is an important area of research. Although many variants of evolutionary algorithms (EA) have been successfully applied to this problem, their demanding memory requirements have restricted their application to real world problems, especially embedded applications with memory constraints. In this paper, structure and parameter learning of a neural network using a novel hybrid compact genetic algorithm (HCGA) is proposed. In the HCGA, each string combines real and binary segments together. For a feed forward neural network, the real segment encodes it weights, while the binary segment encodes the presence/absence of a connection of the network. The proposed hybrid compact genetic algorithm (HCGA) has several advantages: low computational cost, controllable weight regularisation leading to automatic architecture discovery. The HCGA is tested on two benchmark problems of Ripley's synthetic 2-class problem and Mackey glass time series prediction problem. Experimental results show that the proposed algorithm exhibits good performance with low computation cost and controllable network structure.

algorithms, Artificial immune systems field is how can we build autonomous agents whose internal cognition process can be self-configured over time? Our paper proposes a self-organised model for decision making, which is a robust evolutionary extension of typical Behaviours Networks model. Given an initial set of meaningless and unconnected units (behaviours), our system is able to evolutionarily build well-defined and robust behaviour networks which are adapted and specialised to concrete internal agent's needs and goals. As a result, several properties of self-organisation and adaptability emerged when the proposed model was tested in a robotic environment, using a multi-agent platform.

applications, Real-world applications volume of each reservoir in order to establish a coupled behaviour between hydroelectric power plants. This paper proposes the implementation of ROR through a hybrid approach based on fuzzy systems and Particle Swarm Optimization (PSO). Fuzzy inference systems of the Mamdani type are used to estimate the operating volume of each hydroelectric plant, which is based on the value of the stored energy in the hydroelectric system. In order to represent the particular behaviour of each reservoir for the operation of the system in an optimised configuration, a fuzzy system for each hydroelectric plant was designed. The PSO algorithm is used to adjust the membership functions that represent the consequent of the linguistic rules of the fuzzy system. A computational model for simulating the operation of hydroelectric systems is also used to implement the proposed ROR, based on developed Fuzzy-PSO (ROR-FPSO) systems, and to compare them to the Parallel Operation Rules (ROR-PO), to the operation rules based on Mathematical Functions (ROR-MF) and to the operational rules based on Takagi-Sugeno Fuzzy Systems (ROR-TSFS). The results illustrate the effectiveness of the ROR-FPSO, which maximises the hydroelectric benefits associated to hydrothermal generation system, when compared to other ROR already found in literature.

can be automated for use as a fitness function. Judging beauty is a highly subjective task, but certain features are considered important in aesthetic judgement. This paper introduces an adaptive learning evaluation model for guiding the evolutionary process. Certain aesthetic features are extracted from internal evolutionary images and external real world paintings, which are then selected by the model. The model is built by selecting learning approach with better accuracy by training these features. Multi-layer perceptron and C4.5 decision tree are compared for machine learning of aesthetic judgements. Our results show that these features play important roles in aesthetic judgements and the adaptive model is efficient at predicting user's preference.

effects from realistic images. We present an interactive process using flocks of autonomous agents to model a painter's brush. As flocks of agents glide across the canvas like bristles on a paint brush, a stylised picture can be produced by carefully directing the path of movement. The agents leave behind a trail of colour resulting in painterly or pencil sketch looking images.

programming, Art and music implement automated evolution to produce interesting abstract images based on computational aesthetic measures for fitness criteria within a feasible time using a personal computer. The present paper proposes extensions of aesthetic measures for the domain of evolutionary art, for both images and animations. Using two small computers connected via Ethernet, we realised an installation of automatic video art that continuously displays a series of new interesting

animations on the screen by selecting individuals of higher fitness from an evolving population in real time. The art project also includes automated creation of animations that are accessible over the Internet. The project involves the automatic production of ten 20-second movies everyday and posting the digest movie to a popular web site for movie sharing.

solution for the problem is costly or hazardous to construct or extremely computationally intensive to compute. We label such category of problems as expensive in the present study. In the context of multi-objective evolutionary optimisations, the challenge amplifies, since multiple criteria assessments, each defined by an expensive objective is necessary and it is desirable to obtain the Pareto-optimal solution set under a limited resource budget. To address this issue, we proposed a Pareto Rank Learning scheme that predicts the Pareto front rank of the offspring in MOEAs, in place of the expensive objectives when assessing the population of solutions. Experimental study on 19 standard multi-objective benchmark test problems concludes that Pareto rank learning enhanced MOEA led to significant speedup over the state-of-the-art NSGA-II, MOEA/D and SPEA2.

require an algorithm that is able to continuously track a changing optimum over time. In this paper, we investigate a recently proposed algorithm for dynamic continuous optimization, called MLSDO (Multiple Local Search algorithm for Dynamic Optimization). MLSDO is based on several coordinated local search agents and on the archiving of the optima found over time. This archive is used when a change occurs in the objective function. The performance of the algorithm is evaluated on the set of benchmark functions provided for the IEEE WCCI-2012 Competition on Evolutionary Computation for Dynamic Optimisation Problems.

Clearing for solving Dynamic Optimization Problems optimization algorithms to perform search for the best solutions in a time- varying problem space. Among population-based Evolutionary Algorithms (EAs), Differential Evolution (DE) is a simple but highly effective method that has been successfully applied to a wide variety of problems. We propose a technique to solve dynamic optimization problems (DOPs) using a multi-population version of DE that incorporates an ensemble of adaptive mutation strategies with a greedy tournament global search method, as well as keeps track of past good solutions in an archive with adaptive clearing to enhance population diversity.

Process creativity in computers. In this theoretical paper, preparing for a series of experiments, evolution is discussed in the light of a theoretical model of human artistic process, recently presented by the author. Some crucial differences between human artistic creativity and natural evolution are observed and discussed, also in the light of other creative processes occurring in nature. As a tractable way to overcome these limitations, a new kind of evolutionary implementation of creativity is proposed, based on a simplified version of the previously presented model. Artistic creativity is here modelled as an iterated turn-based process, alternating between a conceptual representation and a material representation of the work-to-be. Evolutionary computation is proposed as a heuristic solution to the principal steps in this process, translating back and forth between the two kinds of representation. Those steps are: implementation, going from concept to material form, and re-conceptualisation, forming a new conceptual representation based on the current material form. The advantages and disadvantages of this approach are discussed, and how it could best be implemented.

Intelligence intelligence has received increasing attention. Automatic music composition is a blooming field in computational creativity; especially, automatic accompaniment has gained some promising results. However, most of the automatic accompaniment systems based on evolutionary computation require human feedback as evaluation criterion, which is vulnerable to the fatigue and decreased sensitivity after long-time listening. This study adopts music theory as the basis of evaluation criterion for accompaniment to address this issue. Specifically, we develop a genetic algorithm (GA) to generate polyphonic accompaniment, in which the fitness function consists of several evaluation rules based on music theory. Three accompaniments, i.e., main, bass, and chord accompaniments are considered in the study. Experimental results show that, given a dominant melody, the proposed method can effectively generate multiple scores to form polyphonic accompaniment.

can be used within the class of evolutionary multi-objective optimization (EMO) algorithms. The proposed constraint handling approach is presented within the framework of one of the most successful algorithms i.e. multi-objective evolutionary algorithm based on decomposition (MOEA/D) [1]. The constraint handling mechanism adaptively decides on the violation threshold for comparison. The violation threshold is based on the type of constraints, size of the feasible space and the search outcome. Such a process intrinsically treats constraint violation and objective function values separately and adds a selection pressure, wherein infeasible solutions with violations less than the identified threshold

are considered at par with feasible solutions. As illustrated, the parameter free constraint handling scheme extends the current capability of MOEA/D to deal with constraints. The performance of the algorithm is illustrated using 10 commonly studied benchmark problems and a real-world constraint optimization problem, and compared with the results obtained using yet another commonly used form i.e. Nondominated Sorting Genetic Algorithm (NSGA-II).

VMO algorithm results for complex continuous optimisation problems, using the information of a population of solutions. In these algorithms is crucial the distribution of solutions, that allow them to explore new regions. In this work, we present a population algorithm, Variable Mesh Optimisation, VMO, which the set of nodes (potential solutions) is distributed as a mesh. This mesh is initially distributed in a homogeneous way, and them the mesh evolves to a heterogeneous structure resampling the space toward the best neighbours, but maintaining at the same time a controlled diversity (avoiding solutions too close to each other). Then, we uses a benchmark of multimodal continuous functions to study the influence of the different components of the proposal, and to compare the proposed algorithm with other basic population-based meta-heuristics in the literature. The results show that VMO is a very competitive algorithm.

Evolutionary Computer Vision processing. However, the existing techniques that use the multilevel thresholding method in image segmentation are computationally demanding due to the lack of an automatic parameter selection process. This paper proposes an automatic parameter selection technique called an automatic multilevel thresholding algorithm using stratified sampling and Tabu Search (AMTSSTS) to remedy the limitations. It automatically determines the appropriate threshold number and values by (1) dividing an image into even strata (blocks) to extract samples; (2) applying a Tabu Search-based optimization technique on these samples to maximise the ratios of their means and variances; (3) preliminarily determining the threshold number and values based on the optimised samples; and (4) further Optimising these samples using a novel local criterion function that combines with the property of local continuity of an image. Experiments on Berkeley datasets show that AMTSSTS is an efficient and effective technique which can provide smoother results than several developed methods in recent years.

Collective Intelligence optimise problems with aesthetic criteria by embedding the intelligent evaluations of a user into the evolutionary process. User fatigue caused by frequent interactions, however, often greatly impairs the potentials of IGAs on solving complicated optimization problems. Taking the benefits of collective intelligence into account, we here present an IGA with collective intelligence which is derived from a mechanism of group decision making. An IGA with interval individual fitness is focused here and it can be separately conducted by multiple users at the same time. The collective intelligence of all participated users, represented with social and individual knowledge, is first collected by using a modified group decision making method. Then the strategy of applying the collective intelligence to initialize and guide the single evolution of the IGA is given. With such a multi-user promoted IGA framework, the performance of a single IGA is expected to be evidently improved. In a local network environment, the algorithm is applied to a fashion design system and the results empirically demonstrate that our algorithm is strengthened both in alleviating user fatigue and increasing the opportunities of IGAs on finding most satisfactory solutions.

algorithm is proposed, in which immune clonal selection algorithm is used to optimise the projection vectors. Some orthogonal bases are randomly selected as the initial basis vector sets from the original feature space. The direction of the basis vectors is optimised to generate the optimal projection vector using the immune clonal selection algorithm. Experimental results on benchmark datasets and SAR target recognition on MSTAR dataset verify the effectiveness of the proposed method. This method provides a new idea of applying the immune clonal algorithm to the optimisation of feature vectors.

Generation of Clustering Algorithms distribution algorithms that is, have been developed by a human programmer. A prominent Artificial Intelligence research area is automatic programming: the generation of a computer program by another computer program. Clustering is an important data mining task with many useful real-world applications. Particularly, the class of clustering algorithms based on the idea of data density to identify clusters has many advantages, such as the ability to identify arbitrary-shape clusters. We propose the use of Estimation of Distribution Algorithms for the artificial generation of density-based clustering algorithms. In order to guarantee the generation of valid algorithms, a directed acyclic graph (DAG) was defined where each node represents a procedure (building block) and each edge represents a possible execution sequence between two nodes. The Building Blocks DAG specifies the alphabet of the EDA, that is, any possibly generated algorithm.

Preliminary experimental results compare the clustering algorithms artificially generated by AutoClustering to DBSCAN, a well-known manually-designed algorithm.

Concentration mining highlight differences in the ability of the algorithms and to compare their performance to an established signal to noise based prediction method. Existing data related to weather conditions and ground-level ozone was divided into a training set and a test set. Three algorithms were trained using the training set to create predictors, which were then analysed with the test set, and then compared to the Taguchi Method to determine performance. It was found that the newly introduced Rote-EA performed well on this problem, predictors using the Taguchi method had a smaller deviation from actual results. This indicates an additional factor other than the level of correlation in the data that dictates how well these predictors perform on classification problems.

Images Classification, clustering, data analysis and data mining by the accuracy based on overall pixels in the training stage, rather than the information for each training image. However, when the evaluation for training edge detectors considers the accuracy of each image, the influence on the final detectors has not been investigated. In this study, we employ genetic programming to evolve detectors with new fitness functions containing the accuracy of training images. The experimental results show that fitness functions based on the accuracy of single training images can balance the accuracies across detection results, and the fitness function combining the accuracy of overall pixels with the accuracy of training images together can improve the detection performance.

Classification, clustering, data analysis and data mining repeating certain operations. It is not widely used in Genetic Programming as it introduces extra complexity in the search. However in some circumstances, including a loop structure may enable GP to find better solutions. This study investigates the benefits of loop structures in evolving GP classifiers. Three different loop representations are proposed and compared with other GP methods and a set of traditional classification methods. The results suggest that the proposed loop structures can outperform other methods. Additionally the evolved classifiers can be small and simple to interpret. Further analysis on a few classifiers shows that they indeed have captured genuine characteristics from the data for performing classification.

systems highly dimensional data. Several dimensionality reduction strategies, including popular feature selection metrics such as Information Gain and Chi-squared, have already been proposed to deal with this situation. However, these strategies are not well suited when the data is very skewed, a common situation in real-world data sets. This occurs when the number of samples in one class is much larger than the others, causing common feature selection metrics to be biased towards the features observed in the largest class. In this paper, we propose the use of Genetic Programming (GP) to implement an aggressive, yet very effective, selection of attributes. Our GP-based strategy is able to largely reduce dimensionality, while dealing effectively with skewed data. To this end, we exploit some of the most common feature selection metrics and, with GP, combine their results into new sets of features, obtaining a better unbiased estimate for the discriminative power of each feature. Our proposal was evaluated against each individual feature selection metric used in our GP-based solution (namely, Information Gain, Chi-squared, Odds-Ratio, Correlation Coefficient) using a k8 cancer-rescue mutants data set, a very unbalanced collection referring to examples of p53 protein. For this data set, our solution not only increases the efficiency of the learning algorithms, with an aggressive reduction of the input space, but also significantly increases its accuracy.

Optimisation on Dynamic Multi-Objective Optimisation Problems swarm optimization, Multi-objective evolutionary algorithms multi- swarm variation of particle swarm optimisation (PSO) used to solve static multi-objective optimisation problems (SMOOPs). Recently, VEPSO was extended to the dynamic VEPSO (DVEPSO) algorithm to solve dynamic multi-objective optimisation problems (DMOOPs) that have at least one objective that changes over time. The search process of DVEPSO is driven through local and global guides that can be updated in various ways. This paper investigates the influence of various guide update approaches on the performance of DVEPSO. DVEPSO is also compared against a competitive-cooperative evolutionary algorithm. The results indicate that DVEPSO performs well in fast changing environments, but struggles to converge to discontinuous Pareto-optimal fronts (POFs).

swarm optimization, Dynamic and uncertain environments. evolutionary algorithms (EAs) in dynamic environments. In the literature of EAs for dynamic optimization problems (DOPs), many studies have been done to address this issue based on change detection techniques. However, many changes are hard or impractical to be detected in real-world applications. Although, some research has been done by means of maintaining diversity without change detection. These methods are not effective

because the continuous focus on diversity slows down the optimization process. This paper presents a maintaining diversity method without change detection based on a clustering technique. The method was implemented through particle swarm optimization (PSO), which was named CPSOR. The performance of the CPSOR algorithm was evaluated on the GDBG benchmark. A comparison study with another algorithm based on change detection has shown the effectiveness of the CPSOR algorithm for tracking and locating the global optimum. in dynamic environments.

Environments uncertain environments. based algorithms to solve dynamic problems, the classification of dynamic environments is missing universal standards. This paper examines the various methods used so far to characterise dynamic optimisation problems and proposes an inclusive classification system. Additionally, a way to generate environments of each type using the moving peak benchmark is described.

for the Vehicle Routing Problem with Time Windows The task is to assign customers to multiple vehicles and determine the visiting sequences of customers for the vehicles without violating the vehicle capacity constraint and customer service time window constraints. Two common objectives of VRPTW are to minimise the number of vehicles and the total travelling distance. Most of previous studies assumed that the number of vehicles is more important than the total distance. Hence, they solved the VRPTW by minimising the number of vehicles first and then minimising the total distance under the minimal number of vehicles. Recently, researchers started to solve the VRPTW without this assumption and tried to minimise both objectives simultaneously through searching for the Pareto optimal set of solutions. Following this perspective, we use a multiobjective evolutionary algorithm to solve the VRPTW. We propose enhanced crossover and mutation operators by incorporating the domain knowledge. Performance of the proposed algorithm is verified on a widely used benchmark problem set. Comparing with seven existing algorithms, our algorithm shows competitive performance and contributes many new best known Pareto optimal solutions.

Delivery Problem pickup and delivery problem. This problem relaxes the constraint that all pickup nodes must be visited along the route. Specifically, the SPDP aims to find the shortest route that can supply delivery nodes with required commodities from some selected pickup nodes. Selection of pickup nodes is capable of reducing the transportation cost; on the other hand, it increases the search space and difficulty in resolving the SPDP. In this study, we propose an adaptive mutation that focuses on the selection of proper pickup nodes for the SPDP. Two evolutionary algorithms (EAs), namely genetic algorithm and memetic algorithm, for the SPDP are developed as well. Experimental results show that the proposed adaptive mutation can lead to better selection of pickup nodes for shorter routes, which validates its effectiveness on improving the two EAs for the SPDP.

routing problem uncertain environments., Ant colony optimization with immigrants schemes perform well on different variations of the dynamic travelling salesman problem. In this paper, we address ACO for the dynamic vehicle routing problem (DVRP) with traffic factor where the changes occur in a cyclic pattern. In other words, previous environments will re-appear in the future. Memory-based immigrants are used with ACO in order to collect the best solutions from the environments and use them to generate diversity and transfer knowledge when a dynamic change occurs. The results show that the proposed algorithm, with an appropriate size of memory and immigrant replacement rate, outperforms other peer ACO algorithms on different DVRP test cases

concept of meme, where the individuals forming the population are represented by semantic networks and the fitness measure is defined as a function of the represented knowledge. Our work can be classified as a novel memetic algorithm (MA), given that (1) it is the units of culture, or information, that are undergoing variation, transmission, and selection, very close to the original sense of memetics as it was introduced by Dawkins; and (2) this is different from existing MA, where the idea of memetics has been used as a means of local refinement by individual learning after classical global sampling of EA. The individual pieces of information are represented as simple semantic networks that are directed graphs of concepts and binary relations, going through variation by memetic versions of operators such as crossover and mutation, which uses knowledge from commonsense knowledge bases. In evaluating this introductory work, as an interesting fitness measure, we focus on using the structure mapping theory of analogical reasoning from psychology to evolve pieces of information that are analogous to a given base information. Considering other possible fitness measures, the proposed representation and algorithm can serve as a computational tool for modelling memetic theories of knowledge, such as evolutionary epistemology and cultural selection theory.

Intelligence, Emerging areas computational platform for automatic scenario generation. In particular,

we address a shortcoming of our earlier work relating to scenario representation: the regular story plot grammar. The use of this grammar, which only captures causal relationships between plot elements from the point of view of a single story character, resulted in the generation of stories that are always associated with one main character only, limiting the scalability of the approach. In addition, the regular grammar employed is not suitable for representing practical scenarios since a practical scenario may not require a character at all. To overcome these problems, we propose a new approach to scenario representation. Firstly, we introduce a set of scenario building blocks based on narrative theory. As a result, a scenario can be represented as a network of these building blocks that captures various relationships in the scenario. The task of generating scenarios is then transformed to the task of generating networks of these building blocks. Secondly, we develop two network representation languages extending Boers' GL-2 graph representation systems to describe networks with edges of more than one type and edges between two groups of nodes. Thirdly, a set of two context-free grammars is introduced generate sentences, i.e. scenarios in these languages. Finally, we verify our approach to strategic scenario generation by employing an interactive evolution framework, which shows the proposed scenario representation scheme can facilitate the generation of coherent and novel story-like scenarios.

Differential Evolution continuous optimiser that requires convergence to automatically scale its moves. However, once its population has begun to converge its ability to conduct global search is diminished, as the difference vectors used to generate new solutions are derived from the current population members' positions. In multi-modal search spaces DE may converge too rapidly, i.e., before adequately exploring the search space to identify the best region(s) in which to conduct its finer-grained search. Traditional crowding or niching techniques can be computationally costly or fail to compare new solutions with the most appropriate existing population member. This paper proposes a simple intervention strategy that compares each new solution with the population member it is most likely to be near, and prevents those moves that are below a threshold that decreases over the algorithm's run, allowing the algorithm to ultimately converge. Comparisons with a standard DE algorithm on a number of multi-modal problems indicate that the proposed technique can achieve real and sizable improvements.

evolution (MsSDE) to deal with numerical optimization effectively. Multi-swarm is an effective search concept to keep the original search characteristic or effective balance strategies. However, it still has some defects need to overcome, such as weak search ability for smaller swarm and easy to fall into local optimal position. In order to overcome the problem mention above, the proposed multi-swarm sharing management can adjust each swarm size, share and analyse their information for other swarms to get more effective search ability. Testing and comparing results with original DE and EPUS-PSO by several benchmark functions, it showed that the proposed method has satisfying performance.

Pool of Distances classifier with extension to selecting the applied distance measure from a pool of alternative measures optimally for the particular data set at hand. The proposed method extends the earlier differential evolution based nearest prototype classifier by extending the optimization process to cover also the selection of distance measure instead of optimising only the parameters related with a preselected and fixed distance measure. Now the optimization process is seeking also for the best distance measure providing the highest classification accuracy over the selected data set. It has been clear for some time that in classification, the usual euclidean distance measure is sometimes not the best possible choice. In this paper we apply a systematic optimization process to select the best distance measure from a pool of multiple alternative distance measures. In parallel, within the same optimization process, the optimal parameter values related to each alternative distance measures are determined as well as the optimal class prototype vectors for the given data. The empirical results represented are indicating that with several data sets the optimal distance measure is some other measure than the most commonly applied euclidean distance. The results are also suggesting that from the classification accuracy point of view the proposed global optimization approach is highly potential in solving classification problems of the studied type. Perhaps the most generally applicable conclusion based our results is, that emphasising of selection of distance measure is more important to classification accuracy that it has been commonly believed so far.

is the apparent lack of automated knowledge transfers and reuse across problems. Particularly, evolutionary optimization methods generally start a search from scratch or ground zero state, independent of how similar the given new problem of interest is to those optimised previously. In this paper, we present a study on the transfer of knowledge in the form of useful structured knowledge or latent

patterns that are captured from previous experiences of problem-solving to enhance future evolutionary search. The essential contributions of our present study include the meme learning and meme selection processes. In contrast to existing methods, which directly store and reuse specific problem solutions or problem sub-components, the proposed approach models the structured knowledge of the strategy behind solving problems belonging to similar domain, i.e., via learning the mapping from problem to its corresponding solution, which is encoded in the form of identified knowledge representation. In this manner, knowledge transfer can be conducted across problems, from differing problem size, structure to representation, etc. A demonstrating case study on the arc routing problem (CARP) is presented. Experiments on benchmark instances of CARP verified the effectiveness of the proposed new paradigm.

in optimization. The rise of memetic algorithms, a category of optimization techniques which feature the explicit exploration-exploitation coordination, much accentuates this issue. While memetic algorithms have achieved remarkable success in a wide range of real-world applications, the key to a successful exploration-exploitation synergy still remains obscure. Manifold empirical results and theoretical derivations have been proposed and provided various perspectives from different algorithm-problem complexes to this issue. In our previous work, the concept of local search zones was proposed to provide an alternative perspective depicting the general behaviour of memetic algorithms on a broad range of problems. In this work, based on the local search zone concept, we further investigate how the problem landscape and the way the algorithm explores and exploits the search space affect the performance of a memetic algorithm. The collaborative behaviour of several representative archetypes of memetic algorithms, which exhibit different degrees of explorability and exploitability, are illustrated empirically and analytically on problems with different landscapes. As the empirical results consist with the local search zone concept and describe the behaviour of various memetic algorithms on different problems, this work may reveal some essential design principals for memetic algorithms.

continuous global optimization problems. It comprises evolutionary computation algorithm featuring a novel adaptive elitism strategy and a sequential quadratic programming algorithm; combined in a collaborative portfolio with a validation procedure. The sequential quadratic programming is a gradient based local search method designed to derive effective search directions by using exact Hessians obtained via a vectorised forward accumulation of derivatives technique. The proposed hybrid design aim was to ensure that the two algorithms complement each other by effectively exploring and exploiting the problem search space. Experimental results justify that an adept hybridisation of evolutionary algorithms with a suitable local search method could yield a robust and efficient means of solving wide range of global optimization problems.

evolutionary algorithms, Data mining clustering, MOSSC, is proposed to simultaneously optimise the weighting within-cluster compactness and weighting between-cluster separation incorporated within two different clustering validity criteria. The main advantage of MOSSC lies in the fact that it effectively integrates the merits of soft subspace clustering and the good properties of the multiobjective optimization-based approach for fuzzy clustering. This makes it possible to avoid trapping in local minima and thus obtain more stable clustering results. Substantial experimental results on both synthetic and real data sets demonstrate that MOSSC is generally effective in subspace clustering and can achieve superior performance over existing state-of-the-art soft subspace clustering algorithms.

algorithms increasingly inefficient. More sophisticated approaches are required to cope with the increasing dimensionality and cardinality of such data sets. Feature selection methods are proposed as a solution to deal with this problem, however they fail for data sets where the attribute support for different clusters is not the same. For this category of data sets subspace clustering algorithms have been introduced over the past decade. We approach this problem from the perspective of Genetic Algorithms by adopting a hierarchical data structure deployed in three stages. 1) a traditional clustering algorithm is applied independently to each attribute of the data set, thus defining a grid of potential 1-d cluster centroids. 2) describing multi-dimensional cluster centroids indexing 1-d cluster centroids. 3) converting the problem of finding the best combination of cluster centroids into that of discrete optimization and applying a multi-objective evolutionary algorithm, which uses group fitness evaluation to give a fitness to a group of clusters, as defined by process 2. Synthetic data sets with different characteristics are generated as the ground truth to evaluate the resulting algorithm for Evolutionary Subspace Clustering (ESC) as well as benchmark against alternative subspace and full-space clustering algorithms. ESC returns competitive accuracy while typically using less attributes and scaling as attribute count increases.

juries flood prediction from hydrological data observed timely on water heights in a river watershed.

Since this kind of data recorded by sensors on river basins is highly scarce and hopefully much unbalanced between cases of floods and non-floods, we have adopted the notion of aggregate variables which values are computed as aggregates on raw data. An evolutionary algorithm is involved to allow selecting the best sets, juries of classifiers, of such variables as predictive variables. Two real hydrological data sets are trained and they both show the efficiency of the method compared to traditional solutions for prediction.

Algorithms based on Nonparametric Statistical Tests the comparative evaluation process of the performance of different algorithms. In this paper, three state-of-the-art Differential Evolution (DE) based algorithms, namely Dynamic Memetic Differential Evolution (MOS), Self-adaptive DE hybridised with modified multi-trajectory search (MMTS) algorithm (SaDE-MMTS) and Self-adaptive Differential Evolution Algorithm using Population Size Reduction and three Strategies Algorithm (jDElscop) as well as a novel algorithm called ensemble of parameters and mutation strategies in Differential Evolution with Self-adaption and MMTS (Sa-EPSDE-MMTS), are tested on the most recent LSO benchmark problems and comparatively evaluated using nonparametric statistical analysis. Instead of using the Value-to-Reach as the comparison criterion, comprehensive comparison over multiple evolution points are investigated on each test problem in order to quantitatively compare convergence performance of different algorithms. Our investigations demonstrate that even though all these algorithms yield the same final solutions on a large set of problems, they possess statistically significant variations during the convergence. Hence, we propose that evolutionary algorithms can be compared statistically along the evolution paths.

Population Size a small and varying population size on large scale global optimization. The experimental results obtained by our algorithm on benchmark functions provided for the CEC 2012 competition and special session on Large Scale Global Optimization are presented. The experiments were performed on 20 test functions with high dimension D = 1000. Obtained results show that our algorithm performs highly competitive in comparison with the algorithms presented at similar CEC 2010 competition.

Detection and a Diversity Archive evolution modality detection and a diversity archive (LMDEa) is reported on the set of benchmark functions provided for the CEC2012 Special Session on Large Scale Global Optimisation. In Differential Evolution (DE), large population size, which is much larger than the number of decision variables in problem to be solved, is adopted in order to keep the diversity of search. However, it is difficult to adopt such large size to solve large scaled optimization problems because the population size will become too large and the search efficiency will degrade. In this study, we propose to solve large scale optimization problems using small population size and a large archive for diversity. Also, we propose simple control of scaling factor by observing landscape modality of search points in order to keep diversity. The landscape of a problem to be optimised is often unknown and the landscape is changing dynamically while the search process proceeds. In LMDEa, some points on a line connecting the centroid of search points and a search point are sampled. When the objective values of the sampled points are changed decreasingly and then increasingly, it is thought that one valley exists. If there exists only one valley, the landscape is unimodal and small scaling factor is adopted. Otherwise, large scaling factor is adopted. Also, the sampled points realise global search in the region spanned by all search points and realise local search near the best search point. The effect of the proposed method is shown by solving the benchmark functions.

performance of Differential Evolution (DE) algorithm. The proposed scheme named Modified Random Localisation (MRL) is based on strategically selecting the individuals from the entire search space rather than choosing them randomly as in basic DE. The corresponding DE variant named MRL-DE is analysed on a set of 8 traditional benchmark functions and 6 nontraditional shifted functions. Numerical and statistical results indicate the competence of the proposed MRL-DE for solving unconstrained global optimization problems.

co-fermentation process by hybrid differental evolution optimal temperature control policy for a batch process of simultaneous saccharification and co-fermentation (SSCF) to produce ethanol from lignocellulose using the enzymes and the recombinant strain Saccharomyces yeast 1400 (pLNH33). The goal of the optimal design herein is to find the optimal temperature, initial lignocellulosic concentration, and fermentation time that maximise the ethanol productivity under the constraints of follow-up separation specifications. The interactive crisp and fuzzy optimization methods towards were respectively applied to solve the trade-off optimization problems in order to obtain a compromised design. The fuzzy goal attainment approach can more flexibly obtain a comprehensive design in comparison to the crisp optimization. Both crisp and fuzzy optimization could be efficiently solved by hybrid differential

evolution.

Evolution applications different cities around the word. To prevent a great disaster, it is necessary to construct seismic stations at strategical locations to warn population. Many Disaster Alert Systems (DAS), such as the Seismic Alert System of Mexico City (SAS) or the Deep-ocean Assessment and Reporting of Tsunamis (DART II), were located not based in earthquake or tsunami data, but simply by spacing the sensors more or less evenly around the contour of the Pacific Ocean. The objective of the DAS is simple: to emit an alert as fast as possible, in order to warn the population as early as possible. According to a new location of its seismic stations, the SAS could issue a longer warning time. This research focuses on designing the locations of seismic sensing stations maximising the warning time; that is, the gap between the time when the alert is launched and the arrival time of the disaster. Since locating these stations is basically a numerical problem, in this research, the authors propose a new objective function to maximise the warning time using a differential evolution algorithm. In order to perform the experiments and validate the efficiency of the algorithm, it was considered the epicenters of recorded earthquakes located in the State of Guerrero, Mexico. This data is used in the objective function to set the fitness value of a candidate solution. The main disasters targeted in this paper are earthquakes, but this research can be extended easily to tsunamis or volcanic eruptions alert systems, locating telecommunications antennas, etc.

optimization clustering based on particle swarm optimiser (PSO) and K-means. Particularly, PSO is used as a global search to allow fast exploration of the candidate cluster centers. PSO has strong ability to find high quality solutions within tractable time, but it suffers from slow-down convergence as the swarm approaching optima. K-means, achieving fast convergence to optimum solutions, is used as local search to fine-tune the solutions of PSO in the framework of memetic algorithm. The performance of MCA is evaluated on four synthetic datasets and three high-dimensional gene expression datasets. Comparison study to K-means, PSO, and PSO-KM (jointed PSO and K-means) indicates that MCA is capable of identifying cluster centers more precisely and robustly than the other counterpart algorithms by taking advantage of both PSO and K-means.

for Computationally Expensive Problems (CSAMA) as a manifestation of multi co-objective evolutionary computation to enhance the search on computationally expensive problems by means of transferring, sharing and reusing information across objectives. In particular, the construction of surrogate for one objective is augmented with information from other related objectives to improve the prediction quality. The process is termed as a cross-surrogate modelling methodology, which will be used in lieu with the original expensive functions during the evolutionary search. Analyses on the prediction quality of the cross-surrogate modelling and the search performance of the proposed algorithm are conducted on the benchmark problems with assessments made against several state-of-the-art multiobjective evolutionary algorithms. The results obtained highlight the efficacy of the proposed CSAMA in attaining high quality Pareto optimal solutions under limited computational budget.

Optimization stochastic searching optimization algorithms. However, solving a specific problem using DE crucially depends on appropriately choosing of trial vector generation strategies and their associated control parameters. At the same time, multi- modal optimization refers to locating not only one optimum but a set of optimal solutions. Niching is a useful technique to solve multi-modal optimization problems. Discovering multiple niches is the key capability of niching algorithms. In this paper, we propose a Strategy Adaptive Memetic Crowding DE (SAMCDE), which incorporate Crowding DE (CDE) with strategies and control parameter self-adaptation technique as well as fine search technique to handle multi-modal optimization problems. The algorithm is tested on 10 benchmark multi-modal functions and compared with the original CDE as well as several popular multi-modal optimization algorithms in literature. As shown by the experimental results, the proposed algorithm is able to generate superior performance on the tested functions.

pattern recognition, image analysis and statistical data analysis. Image clustering is an application of image analysis in order to support high-level description of image content for image understanding where the goal is finding a mapping of the images into clusters. This paper presents an Artificial Bee Colony (ABC) based image clustering method to find clusters of an image where the number of clusters is specified. The proposed method is applied to three benchmark images and the performance of it is analysed by comparing the results of K-means and Particle Swarm Optimization (PSO) algorithms. The comprehensive results demonstrate both analytically and visually that ABC algorithm can be successfully applied to image clustering.

technological developments. Although big size data may be helpful while retrieving information,

storing, processing, transmission etc., is expensive. Therefore, image compression techniques are introduced to represent the data by less bits. One of the compression techniques, wavelet transform, is used especially to compress images. By the wavelet packets decomposition, both approximation and detail coefficients of an image are extracted repeatedly up to a filtering level. In order to decompose an image by wavelet packets, there are some parameters to be set such as main wavelet type, filtering level, and threshold values at each level. Selecting the best values for these parameters affects the performance of the compression. Therefore, assigning the parameters that yield the optimum compression is a design problem. Moreover, since the filtering type and filtering level are related with the topology of the filter and the level of filtering changes the number of parameters to be optimised, the problem can be considered as a structural optimization problem. In order to solve this problem, two swarm-intelligence based optimization algorithms, Particle Swarm Optimization and Artificial Bee Colony algorithms, are employed and compared in terms of compression and quality metrics.

Optimization Problems complicated problems, nature-inspired optimization methods were proposed and widely accepted in recent years. In this work, we investigate the trade-off between risk and return in a cardinality-constrained portfolio optimization problem and applied an artificial bee colony (ABC) method as the solution approach. It would be the first attempt of ABC on this application. The proposed ABC algorithm employs a hybrid encoding that mixes integer and real variables to fulfil the characteristic of the portfolio optimization problem. The generation of solutions involves three groups of bees: employed bees, onlooker and scouts that balance the effects of exploration and exploitation. The study tests the performance of the proposed ABC algorithm on four global stock market indexes provided by the OR-Library. Computational results of ABC are compared with simulated annealing (SA), tabu search (TS), and variable neighbourhood search (VNS) methods in the literature. Evidences indicate that ABC performs better in terms of diversity, convergence, and effectiveness among all three test data sets; therefore, ABC demonstrates its potential on portfolio optimization.

computational problems: one long-term (pheromone) and the other short-term (local heuristic). This paper details the development of a, a mid-term heuristic based on an analogous process in real ants. This is incorporated into ACO for the Travelling Salesman Problem (TSP). A involves sharing information of the previous paths taken by ants, including information gained from previous meetings. A was added to the Ant System (AS), Ant Colony System (ACS) and Ant Multi-Tour System (AMTS) algorithms. Tests were conducted on symmetric TSPs of varying size. Antennation provides an advantage when incorporated into algorithms without an inbuilt exploration mechanism and a disadvantage to those that do. AS and AMTS with antennation have superior performance when compared to their canonical form, with the effect increasing as problem size increases.

ACO in Continuous Domain foraging behaviour of ants. This metaheuristic was originally proposed to find good solutions to discrete combinatorial problems. Many extensions of the ACO heuristic for continuous domain have been proposed, but even those that claim close similarity with classical (discrete domain) ACO, like ACOR, do not use the heuristic information called visibility, commonly used in the original ACO algorithm. In this paper, we show the importance of the visibility in ACO, by proposing ACOR-V, a variant of ACOR that performs better in a number of benchmark functions. Results from our experiments shown better solutions when comparing ACOR-V to original ACOR. Moreover, the visibility increased the convergence speed as it reduced the number of times the objective function must be evaluated for a given precision in the solution.

Ant Colony Optimization and Genetic Algortihm genetic algorithm (GA) (HACOGA) for solving capacitated vehicle routing problem (CVRP) with time window, fuzzy travel time and demand. A mathematical model for CVRP with time window, fuzzy travel time and demand is first constructed. It applies fuzzy credibility and ranking approaches. Then, the proposed HACOGA which combines ACO with GA to accelerate its exploration is employed. It also embeds local search algorithms to generate a better initial solution and improve its performance at the end of evolution. The proposed algorithm is verified using an instance of CVRP with time window and fuzzy travel time first. The simulation result indicates that the proposed HACOGA outperforms previous methods. Furthermore, a simulation example is employed to show the effectiveness of the proposed algorithm for solving CVRP with time window, fuzzy travel time and fuzzy demand. The computational results reveal that HACOGA still has the best performance.

Acceleration its frequency components in order to accelerate evolutionary computation (EC) and evaluate the performance of the technique. In addition to the EC individuals, the entire fitness landscape is resampled uniformly. The frequency information for the fitness landscape can then be

obtained by applying the discrete Fourier transform (DFT) to the resampled data. Next, we filter to isolate just the major frequency component; thus we obtain a trigonometric function approximating the original fitness landscape after the inverse DFT is applied. The elite is obtained from the approximated function and the EC search accelerated by replacing the worst EC individual with the elite. We use benchmark functions to evaluate some variations of our proposed approach. These variations include the combination of resampling of the global area, local area, in all n-D at once, and in each of n 1-D. The experimental results show that our proposed method is efficient in accelerating most of the benchmark functions.

Sub-Region partitioned into sub-regions according to the distribution of evaluated solutions. The partitioned sub-region serves as mutation range such that the corresponding mutation is adaptive and parameter-less. As pointed out by Chow and Yuen, the boundary condition of the mutation in cNrGA is too restricted that the exploitative power of cNrGA is reduced. In this paper, we tackle this structural problem of cNrGA by a new formulation of mutation range. When sub- region is formulated as which certain overlap exists between adjacent sub- regions, this creates a soft boundary and it allows individual move from a sub-region to another with better fitness. This modified cNrGA is named cNrGA with overlapped search sub-region (cNrGA/OL/OGF). By comparing with another work on this problem, Continuous non-revisiting genetic algorithm with randomly re-partitioned BSP tree (cNrGA/RP/OGF), it has an advantage on processing speed. The proposed algorithm is examined on 34 benchmark functions at dimensions ranging from 2 to 40. The results show that the proposed algorithm is superior to the original cNrGA, cNrGA/RP/OGF and covariance matrix adaptation evolutionary strategy (CMA-ES).

Functions metaheuristics and hyper-heuristics mimics the interactions of molecules in chemical reactions to search for the global optimum. The perturbation function greatly influences the performance of CRO on solving different continuous problems. In this paper, we study four different probability distributions, namely, the Gaussian distribution, the Cauchy distribution, the exponential distribution, and a modified Rayleigh distribution, for the perturbation function of CRO. Different distributions have different impacts on the solutions. The distributions are tested by a set of well known benchmark functions and simulation results show that problems with different characteristics have different preference on the distribution function. Our study gives guidelines to design CRO for different types of optimization problems.

training feedforward neural networks shortcomings of gradient based leaning methods in training feed forward neural networks (NN). However, the complicated properties of NN training, such as context dependence problem between neurons and permutation problem of genetic representation, will cause difficulties in efficiently implementing conventional GAs. In the present study, a novel hybrid GA design is proposed to overcome these problems. First, for the sake of eliminating the context dependence, the new method adopts GA and least squares estimator to separately optimise the neurons in hidden and output layers. Second, in order to completely avoid the permutation problem, the proposed GA design employs two heterogeneous populations that evolve in company but respectively learn the optimal combinations and parameters of hidden neuron. Finally, experimental studies encouragingly show that, in comparison with five well-known conventional approaches, the new training method displays a much better approximation and generalisation capabilities in nonlinear static and dynamic modelling, especially for the observed signals corrupted with large measurement noises.

Immune Based clustering, data analysis and data mining advancements. However, this evolution has also contributed to the rise of the identity theft. An alternative to curb identity theft is by the identification of anomalous user behaviour on the computer, what is known as behavioural intrusion detection. Among the features to be extracted from the user behaviour, this paper focuses on keystroke dynamics, which analysis the user typing rhythm. This work uses a neural network to recognise users by keystroke dynamics and draws a comparison among several training algorithms: single backpropagation, three approaches based on genetic algorithms and three approaches based on immune algorithms.

approach for data clustering data mining, Convergence, scalability and complexity analysis and/or not differentiable. A major obstacle for many clustering techniques is that they are computationally expensive, hence limited to smaller data volume and dimension. We propose a lightweight swarm clustering solution called Rapid Centroid Estimation (RCE). Based on our experiments, RCE has significantly quickened optimization time of its predecessors, Particle Swarm Clustering (PSC) and Modified Particle Swarm Clustering (mPSC). Our experimental results show that on benchmark

datasets, RCE produces generally better clusters compared to PSC, mPSC, K-means and Fuzzy C-means. Compared with K-means and Fuzzy C-means which produces clusters with 62percent and 55percent purities on average respectively, thyroid dataset has successfully clustered on average 71percent purity in 14.3 seconds.

multi-meme and hybrid algorithms, Numerical optimization. algorithms for solving the hardest optimization problems. On the other hand, artificial bees colony (ABC) algorithms demonstrate good performances when solving continuous and combinatorial optimization problems. This study tries to use these technologies under the same roof. As a result, a memetic ABC (MABC) algorithm has been developed that is hybridised with two local search heuristics: the Nelder-Mead algorithm (NMA) and the random walk with direction exploitation (RWDE). The former is attended more towards exploration, while the latter more towards exploitation of the search space. The stochastic adaptation rule was employed in order to control the balancing between exploration and exploitation. This MABC algorithm was applied to a Special suite on Large Scale Continuous Global Optimisation at the 2012 IEEE Congress on Evolutionary Computation. The obtained results the MABC are comparable with the results of DECC-G, DECC-G*, and MLCC.

Solving Large Scale Problems optimization, Multiobjective optimization problem's dimension increases to large scale. For high dimensional search space, an algorithm may not be easy to locate at regions which contain good solutions. The exploitation ability is also reduced due to large search space. No Free Lunch theorem implies that we can make better algorithm if an algorithm knows the information of the problem. Algorithms should have an ability of learning to solve different problems, in other words, algorithms can adaptively change to suit the landscape of problems. In this paper, the strategy of dynamical exploitation space reduction is used to learn problems' landscapes. While at the same time, partial re-initialisation strategy is used to enhance the algorithm's exploration ability. Experimental results show that a PSO with these two strategies has better performance than the standard PSO in large scale problems. Population diversities of variant PSOs, which include position diversity, velocity diversity and cognitive diversity, are discussed and analysed. From diversity analysis, we can conclude that an algorithm's exploitation ability can be enhanced by exploitation space reduction strategy.

Optimization and collective behaviour, Numerical optimization. problems, a number of techniques have been invented, among which, Cooperative Coevolution (CC in short) is obviously a promising one. But sometimes CC is easy to lead to premature convergence in large scale function optimization. In this paper, we present a CCEA with global search (CCGS) to handle large scale global optimization (LSGO) problems. The performance of CCGS is evaluated on the test functions provided for the CEC 2012 competition and special session on Large Scale Global Optimisation. The experiment results show that this technique is more effective than CCEAs without global search.

Problem with Time Windows solving the travelling salesman problem with time windows (TSPTW) in order to minimise the total travel cost of a given tour. TSPTW is a difficult optimization problem arising in both scheduling and logistics applications. The proposed DABC algorithm basically relies on the destruction and construction phases of iterated greedy algorithm to generate neighbouring food sources in a framework of ABC algorithm. In addition, it also relies on a classical 1-opt local search algorithm to further enhance the solution quality. The performance of the algorithm was tested on a benchmark set from the literature. Experimental results show that the proposed DABC algorithm is very competitive to or even better than the best performing algorithms from the literature

feasible solutions. However, there is still an insufficiency in ABC regarding improvement in exploitation and convergence speed. In order to improve the performance of ABC we used mean mutation operator (MMO), which uses a linear combination of Gaussian and Cauchy distributions. This convoluted distribution produces larger mutations than the Gaussian distribution, and smaller mutations than the Cauchy distribution, which in simpler words justifies/balances exploration and exploitation in ABC. Experiments are conducted on a set of 6 benchmark functions. The results demonstrate good performance of MABC in solving numerical optimization problems when compared with three ABC-based algorithms.

function optimization. The algorithm is inspired by the foraging behaviour of honey bees. In this work, the performance of ABC is enhanced by introducing the concept of generalised opposition-based learning. This concept is introduced through the initialisation step and through generation jumping. The performance of the proposed generalised opposition-based ABC (GOABC) is compared to the performance of ABC and opposition-based ABC (OABC) using the CEC05 benchmarks library.

using ant colony optimization. The objective of this methodology is to choose the facilities that will

take part in a multi-product closed-loop supply chain, such as factories, warehouses and disassembly centers, in order to minimise the costs related to these facilities and those related to transportation costs, both in the forward and reverse chains. Considering that total production quantities for factories, expected cross-docking stocks for warehouses, and disassembly centers are determined by this methodology, it can be considered that it undertakes both strategic and tactical Supply Chain Management (SCM) problems at once. The developed algorithm, SCant-Design, is sufficiently general to solve any SCM configuration, with linear and nonlinear cost functions and constraints. The algorithm results were compared to a MILP approach for a particular case study and the obtained value for the cost function is very similar, although using less facilities.

Multi-objective Evacuation Routing Optimization Problem optimization out optimal evacuation routes for a group of evacuees according to multiple evacuation objectives. For improving the evacuation efficiency, we abstracted the evacuation zone as a positive-point-charge-potential-field-like model (PPCPF-like model), and we proposed PPCPF-ACO algorithm to solve this problem based on the proposed model. In PPCPF-ACO algorithm, we use non-dominated sorting based roulette wheel routing method (NSRWR) to further improve evacuation efficiency. In Wuhan Sports Centre case, we compared PPCPF-ACO with HMERP-ACO (hierarchical multi-objective evacuation routing problem, ant colony optimization) and traditional ACO according to three evacuation objectives, namely, total evacuation time, total evacuation route length and cumulative congestion degree. The experimental results show that PPCPF-ACO has a better performance than HMERP-ACO algorithm and traditional ACO algorithm while solving multi-objective evacuation routing optimization problem.

researcher had successfully used genetic algorithm (GA) in design of filters. Nevertheless, filters obtained by GA are always complex and require lengthy computations. Ant colony optimization (ACO) is a novel searching technique used in optimization problems. In this paper, an ACO approach for optimization of analog filters is presented. In a design example, the order of a lowpass filter and the parameters of its components have been optimised in a discrete search space. AC analysis of the optimised filter has been conducted, and the results have been compared with a filter obtained by GA. The results show that filters obtained by ACO have simpler structures and better performance.

clustering, data analysis and data mining modern person or company. At the same time the number of network threats and attacks of various types in private and corporate networks is constantly increasing. Therefore, the development of effective methods of intrusion detection is an urgent problem at the present day. In this paper we propose a new approach to intrusion detection in computer networks based on the use of neural networks ensembles. This approach can be implemented in distributed intrusion detection systems (IDS) which better meets the challenges of the present time, in contrast to the traditional use of neural networks in host- based IDS. In the paper the basic steps of the neural networks ensembles designing are described and some of the methods to complete these steps are expounded. Peculiarities of using neural networks ensembles to solve classification problems are discussed. Then the basic scheme of neural networks ensemble approach to intrusion detection systems is proposed. Conditions and results of experimental investigation of the proposed approach on a number of classification problems are presented, including the problem of classifying probe attacks. Possible development of the proposed approach and areas for future research are discussed in the end.

Neural Systems (IEEE-CEC), Heuristics, metaheuristics and hyper-heuristics metaheuristic for global optimization, to design Fuzzy Rule-Based Systems (FRBSs). CRO imitates the interactions of molecules in a chemical reaction. The molecular structure corresponds to a solution, and the potential energy is analogous to the objective function value. Molecules are driven toward the lowest energy stable state, which corresponds to the global optimum of the problem. In the realm of modelling with fuzzy rule-based systems, automatic derivation of fuzzy rules from numerical data plays a critical role. We propose to use CRO with Cooperative Rules (COR) to solve the fuzzy rule learning problem in FRBS. We formulate the learning process of FRBS in the form of a combinatorial optimization problem. Our proposed method COR-CRO is evaluated by two fuzzy modelling benchmarks and compared with other learning algorithms. Simulation results demonstrate that COR-CRO is highly competitive and outperforms many other existing optimization methods.

techniques using Bayesian approach. The algorithms considered are restricted to projective measurements in a fixed basis, and are derived under the assumption that the qubit measurement is much slower than the characteristic qubit evolution. The non-adaptive algorithm is optimised using particle swarm optimization (PSO) and compared to previously developed locally-optimal scheme.

Function Networks applications, Evolutionary Algorithms with Statistical & Machine Learning

Techniques source for survival analysis. However, gene expression data is characterised with thousands of features/genes but only tens or hundreds of observations. The high-dimensionality and unbalance between features and samples pose big challenges for the classical survival analysis methods. This paper proposes a particle swarm optimization based radial basis function networks (PSO-RBFN) for the survival analysis on gene expression data. Particularly, PSO-RBFN applies a principle component analysis for dimensionality reduction and optimises the RBF network using PSO. The experimental results on three gene expression datasets indicate that PSO-RBFN is able to improve the predict accuracy compared to the other classical survival analysis methods.

Wireless Ad-Hoc Networks optimization (PSO) for solving the minimum energy broadcast (MEB) problem, which has been proved to be NP-complete. Wireless sensor networks (WSNs) have attracted large intention in recent years due to its powerful ability. One crucial issue in WSN is energy saving because of the limited battery resource. The MEB problem is one of the important scenarios in WSN, where a node needs to broadcast packets to all other nodes in the network. The objective is to minimise power consumption of all nodes in the network. Here we take advantage of fast and guided convergence characteristics of PSO to solve the MEB problem. For applying PSO to the MEB problem, we use the power degree to define the particle position. We go a step further to analyse one well-known local search mechanism: r-shrink and propose an improved version. The experimental results show that the proposed approach is able to compete and even outperform state-of-the-art works.

Sequential Multi-Issue Negotiation optimization and Particle Swarm Optimisation (PSO) to evolve optimal agenda in bilateral multi-issue negotiation. In sequential negotiation the agenda specifies the set of issues included in the negotiation and the order of which they will be discussed. A player's profit from negotiation depends on the agenda. Each player wants to find an agenda that yields the highest profit, i.e., his/her optimal agenda. Our proposed technique identifies the best set of issues to be included in the agenda as well as the best order of the issues in a way that increases the player's profit. The proposed technique is comprised of two GA systems. Firstly, we have an outer GA system that searches for the best set of issues to be included in the agenda. Secondly, we have an inner GA system that searches for the best order of the selected issues. PSO is used to automatically adjust the parameters of these two GA systems. Empirical evidence demonstrates that the proposed technique evolves better agendas than standard GA, 1+1 Evolutionary Strategy, Fixed Settings Hyper-GA and a simple random search.

Particle Swarm Optimization based on the Gaussian particle swarm optimization (GPSO). Through the Taylor expansion, NMPC transform to a quadratic programming problem with unknown parameters. Hence, for the global convergence character and higher optimization accuracy, GPSO is employed to dynamically perform nonlinear constraint optimization. Finally, the proposed control strategy is applied to Ball-Plate system to verify the effectiveness.

Environments multi-attribute scenarios in which negotiators act largely selfishly but make concessions in the interests of long-term gains. These semi-competitive environments have increasingly complex goal structures in which a single negotiator has difficulty identifying his own ideal goals. In combination with the conflicting goals of other parties to the negotiations, the situation presents itself as a complex multi-objective scenario with incomplete information. Most existing approaches to this problem either assume linear or monotonic functions or they employ an unbiased mediator to select a single proposal as the basis of an agreement. Existing approaches also assume that each negotiating party can identify her own acceptance limit or reservation utility. The current work overcomes these limitations by introducing a distributed approach which integrates another party's proposals into the local optimisation process. It employs a dynamic coceding strategy which is not dependent on the identification of a reservation utility.

Probability Model Multi-objective evolutionary algorithms simultaneously. Multiobjective evolutionary algorithm based on decomposition (MOEA/D) is a new framework for dealing with such kind of multiobjective optimization problems (MOPs). MOEA/D focuses on how to maintain a set of scalarised sub-problems to approximate the optimum of a MOP. This paper addresses the offspring reproduction operator in MOEA/D. It is arguable that, to design efficient offspring generators, the properties of both the algorithm to use and the problem to tackle should be considered. To illustrate this idea, a generator based on multivariate Gaussian models is proposed under the MOEA/D framework in this paper. In the new generator, both the local and global population distribution information is extracted by a set of Gaussian distribution models; new trial solutions are sampled from the probability models. The proposed approach is applied to a set of benchmark problems with complicated Pareto sets. The

comparison study shows that the offspring generator is promising for dealing with continuous MOPs.

Bi-Objective and Penalty Function Approach handling proposed in the present study. In most constrained optimization problems, constraints may be of different scale. Normalisation of constraints is crucial for the efficient performance of a constraint handling algorithm. A growing number of researchers have proposed different strategies using bi-objective methodologies. Classical penalty function approach is another common method among both evolutionary and classical optimization research communities due to its simplicity and ease of implementation. In the present study, we propose a hybrid approach of both bi-objective method and the penalty function approach where constraints are normalised adaptively during the optimization process. The proposed bi-objective evolutionary method estimates the penalty parameter and the starting solution needed for the penalty function approach. We test and compare our algorithm on seven mathematical test problems and two engineering design problems taken from the literature. We compare our obtained results with our previous studies in terms of function evaluations and solution accuracy. The obtained optima are also compared with those of other standard algorithms. In many cases, our proposed methodology perform better than all algorithms considered in this study. Results are promising and motivate further application of the proposed adaptive normalisation strategy.

and a Maximin Selection Criterion scheme and a clustering technique), which is incorporated into a differential evolution algorithm to solve multi-objective optimization problems. The resulting algorithm is called Maximin-Clustering Differential Evolution (MCDE) and, is validated using standard test problems and performance measures taken from the specialised literature. Our preliminary results indicate that MCDE is able to outperform NSGA-II and that is competitive with a hypervolume-based approach (SMS-EMOA), but at a significantly lower computational cost.

Expensive Problems, Interactive evolutionary computation evaluations with the evolutionary optimization mechanisms, have been sufficiently investigated due to their prominent performance in solving problems with aesthetic criteria. User fatigue arising from intelligent evaluations, however, greatly restricts IGAs to successfully optimise complicated problems. Lot of efforts have been devoted to effectively alleviating user fatigue and improving the exploration performance by designing friendly evaluation modes or surrogate models. A large population IGA with a novel evaluation mode and a ranking learning based surrogate model is presented here. A hierarchical evaluation mode reflecting the preference orderings of the user is first presented. From the perspective of directly maintaining the correct preference ordering, a ranking function is constructed to estimate the fitness of all individuals. An enhanced semi-supervised ranking SVM is developed to obtain the ranking function with high prediction accuracy, in which the method of selecting most informative unlabelled samples is highlighted by naturally combining the merits of IGAs. The ranking function is managed based on a defined metric of prediction accuracy. The proposed algorithm is applied to a fashion design system to empirically demonstrate its strength in alleviating user fatigue and improving exploration.

Values using Surrogate Models Optimisation of Expensive Problems, Discrete and combinatorial optimization. evaluate, Surrogate Models (SMs) mimic the behaviour of the simulation model as closely as possible while being computationally cheaper to evaluate. Due to their nature, SMs can be seen as heuristics that can help to estimate the fitness of a candidate solution without having to evaluate it. In this paper, we propose a new SM based on genetic programming (GP) and Radial Basis Function Networks (RBFN), called GP-RBFN Surrogate. More specifically, we use GP to evolve both: the structure of a RBF and its parameters. The SM evolved by our algorithm is tested in one of the most studied NP-complete problem (MAX-SAT) and its performance is compared against RBFN Surrogate, GAs, Random Search and (1+1) ES. The results obtained by performing extensive empirical experiments indicate that our proposed approach outperforms the other four methods in terms of finding better solutions without the need of evaluating a large portion of candidate solutions.

models of IGAs Interactive evolutionary computation, Meta-modelling and surrogate models optimization problems with qualitative indices. The problem of user fatigue resulting from his/her evaluations, however, restricts their applications in complex optimization problems. Employing various surrogate models to evaluate (a part of) individuals instead of a user is a feasible approach to solving the above problem. Previous studies, however, have not fully used knowledge provided by users with similar preference when constructing these models. The problem of constructing surrogate models by using knowledge of users with similar preference was focused in this study. First, users with similar preference participating the evolution were identified based on the matrix formed by the relationship between users and the fitness of allele meaning units and the users' interests in allele meaning units by using the

collaborative filtering algorithm based on nearest-neighbour; and then the individuals evaluated by users with similar preference and chosen according to the users' preference similarities and confidence, along with their fitness, were as a part of samples for training the surrogate model of the current user's cognition. The proposed method was applied to an evolutionary fashion design system, and the experimental results show that the proposed method can improve the capability in exploration on the premise of greatly alleviating user fatigue.

Categorization Multiobjective optimization training data is expensive and time consuming. Semi-supervised learning is a machine learning paradigm which deals with using unlabelled data to build better classifiers. However, unlabelled data with wrong predictions will mislead the classifier. In this paper, we proposed a particle swarm optimization based semi-learning classifier to solve Chinese text categorisation problem. This classifier uses an iterative strategy, and the result of classifier is determined by a document's previous prediction and its neighbours' information. The new classifier is tested on a Chinese text corpus. The proposed classifier is compared with the k nearest neighbour method, the k weighted nearest neighbour method, and the self-learning classifier.

process of selecting an appropriate set of features for text classification becomes more important, for not only reducing the dimensionality of the feature space, but also for improving the classification performance. This paper proposes a novel feature selection approach to improve the performance of text classifier based on an integration of Ant Colony Optimization algorithm (ACO) and Trace Oriented Feature Analysis (TOFA). ACO is metaheuristic search algorithm derived by the study of foraging behaviour of real ants, specifically the pheromone communication to find the shortest path to the food source. TOFA is a unified optimization framework developed to integrate and unify several state-of-the-art dimension reduction algorithms through optimization framework. It has been shown in previous research that ACO is one of the promising approaches for optimization and feature selection problems. TOFA is capable of dealing with large scale text data and can be applied to several text analysis applications such as text classification, clustering and retrieval. For classification performance yet effective, the proposed approach makes use of TOFA and classifier performance as heuristic information of ACO. The results on Reuters and Brown public datasets demonstrate the effectiveness of the proposed approach.

and data mining, Data mining clusters in datasets automatically, and without requiring users to specify the number of clusters. While conventional wisdom suggests that swarm intelligence contributes to this ability, recent works have provided alternative explanation about underlying stochastic heuristics that are really at work. This paper shows that the working principles of several recent SBC methods can be explained using a stochastic clustering framework that is unrelated to swarm intelligence. The framework is theoretically simple and in practice easy to implement. We also incorporate a mechanism to calibrate a key parameter so as to enhance the clustering performance. Despite the simplicity of the enhanced algorithm, experimental results show that it outperforms two recent SBC methods in terms of clustering accuracy and efficiency in the majority of the datasets used in this study.

Unseen Problems score algorithms are one of the main approaches proposed for learning BN structure from data. Previous research has shown that the relative performances of such algorithms are problem dependent and that fitness landscape analysis can be used to characterise the difficulty of the search for different scoring functions. In this paper, we construct a classifier based on fitness landscape analysis and receiver operating characteristic curves. The classifier labels search landscapes with the most suitable scoring function. We train the classifier on a number of standard benchmark functions. The classifier forms the basis for a selective hyperheuristic algorithm. This uses an initial landscape analysis stage to select a scoring function using the classifier. The hyperheuristic algorithm is tested on a distribution of unseen problems based on mutations of the standard benchmarks. Our results establish that the hyperheuristic performs better than a uniformly random scoring function selection approach that omit the landscape analysis stage. Therefore the effects on performance of problem-dependency can be significantly reduced.

SNP selection Estimation of distribution algorithms, Biometrics, bioinformatics and biomedical applications evolutionary optimization using estimation of distribution algorithms. We propose a framework for transfer learning between related optimization problems by means of structural transfer. Different methods for incrementing or replacing the (possibly unavailable) structural information of the target optimization problem are presented. As a test case we solve the multi-marker tagging SNP selection problem, a real world problem from genetics. The introduced variants of structural transfer are validated in the computation of tagging SNPs on a database of 1167 individuals from 58 human

populations worldwide. Our experimental results show significant improvements over EDAs that do not incorporate information from related problems.

Sudoku Puzzles Games value are studied in this paper. A new mutation technique called the Exponential Moving Average algorithm (EMA) is introduced. The performance of EMA algorithms is compared to two other similar Computational Intelligence (CI) algorithms (an ordinary Evolutionary Algorithm (EA) and a Mean-Variance Optimisation (MVO)) to solve a multi-dimensional problem which has a large search space. The classic Sudoku puzzle is chosen as the problem with a large search space.

Network Analysis and Applications community links than inter-community links. Tracking communities in a network via a community life-cycle model can reveal patterns on how the network evolve. Previous models of community life-cycle provided a first step towards analysing how communities change over time. We introduce an extended life-cycle model having the minimum community size as a parameter. Our model is capable of uncovering anomaly in community evolution and dynamics such as communities with stable or stagnant size. We apply our model to track, and uncover trends in, the evolution of communities of genetic programming researchers. The lifespan of a community measures how long it has lived. The distribution of lifespan in the network of genetic programming researchers is shown to be modelled as an exponential-law, a phenomenon yet to be explored in other empirical networks. We show that our parameter of minimum community size can significantly affect how communities grow over time. The parameter is fine-tuned to detect anomaly in community evolution.

the Multiobjective Subdue Algorithm vast amount of scientograms for scientific data analysis has been of great interest in Information Science. This work emphasises the application of multiobjective subgraph mining for the scientogram analysis task regarding the extraction of common research areas in the world. For this task, we apply a recently proposed multiobjective Subdue (MOSubdue) algorithm for frequent subgraph mining in graph-based data. The algorithm incorporates several ideas from evolutionary multiobjective optimization. The underlying scientogram structure is a social network, i.e., a graph, MOSubdue can uncover common (or frequent) scientific structures to different scientograms. MOSubdue performs scientogram mining by jointly maximising two objectives, the support (or frequency) and complexity of the mined scientific structures. Experimental results on five real-world datasets from Elsevier-Scopus scientific database clearly demonstrated the potential of multiobjective subgraph mining in scientogram analysis.

Algorithm Heuristics, metaheuristics and hyper-heuristics, Engineering applications multilevel thresholding. The main difference between multilevel and binary thresholding, is that the binary thresholding outputs a two-colour image, usually black and white, while the multilevel thresholding outputs a grey scale image in which more details from the original picture can be kept. Two major problems with using the multilevel thresholding technique are: it is a time consuming approach, i.e., finding appropriate threshold values could take exceptionally long computational time; defining a proper number of thresholds or levels that will keep most of the relevant details from the original image is a difficult task. In this study a new approach based on the Kullback-Leibler information distance, also known as Relative Entropy, is proposed. The approach minimises a mathematical model, which will determine the number of thresholds automatically. The optimization of the mathematical model is achieved by using a newly developed meta-heuristic named Virus Optimisation Algorithm (VOA), where its performance is compared with Genetic Algorithm (GA). From the experiments performed in this study, the proposed method does not only provide good segmentation results but also its computational effort makes it a very efficient approach.

Polycephalum organism, displays remarkable intelligent behaviours such as solving mazes, shuttle streaming and event anticipation. These amoeboid behaviours are results of the dynamics of the viscoelastic protoplasm and its biochemical rhythms. Having inspired by the intelligence shown by this primitive organism without a nerve system to solve mazes, we proposed mathematical models to mimic the intelligent foraging behaviour that can be used to find the shortest path between two points of a graph. In result, we found that the convergence of the proposed two versions, Physarum Optimisation with Shuttle Streaming (POSS) and POSS with mutation, are 40-11650 times faster when compared with the currently available Physarum Solver (PS) method and the results obtained are comparable.

on Rule-based Ecological Modelling optimization (PO) within the hybrid methodology developed for modelling algal abundance by rule-based models. These PO algorithms include: (1) Hill Climbing (2) Simulated Annealing (3) Genetic Algorithm (4) Differential Evolution (5) Covariance Matrix

Adaptation Evolution Strategy and (6) Estimation of Distribution Algorithm. The effectiveness of algorithms is tested on the Cylindrospermopsis abundance data from Wivenhoe Reservoir in Queensland (Australia). We provide a systematic analysis and comparison of different parameter optimization algorithms as well as the resulting predictive rule models.

Multi-Objective Optimization on Discrete Problems optimization. Client-Server model for multi-objective optimization problems. Firstly, the PQEA uniformly decomposes a multi-objective optimization problem into a number of scalar optimization sub-problems. All the sub-problems are classified into several groups according to their similarities. Each Client processes the evolution for a group of neighbour sub-problems in parallel. There is a quantum individual used to address the sub-problems of a group in a Client. Since the quantum individual is a probabilistic representation, it can share evolutionary information of the neighbour sub-problems in one group, while the sub-problems are orderly solved using a same q-bit individual. The Server maintains non-dominated solutions that are generated by every Client. The current best solution for each sub-problem can be found in the Server, when the quantum individual updated its states for evolution. Experimental results have demonstrated that PQEA obviously outperforms the most famous multi-objective optimization algorithms, MOEA/D, NSGA-II and MOGLS on the bi-objectives. For the more objectives, the PQEA obtains the similar results with MOEA/D, even with the same evaluation times. Furthermore, in this paper, the scalability and sensitivity of PQEA have also been experimentally investigated.

creations, despite the high degree of similarity between variants of the algorithm. Although a canonical form of the algorithm is generally understood, differences in the execution of the experiment may produce unique results. It is valuable to establish a common understanding of the informational representation and execution of the algorithm, for the purposes of experiment consistency, repeatability and communication. This paper formulates a generalised model for computational expression of the algorithm. An encoding scheme and protocol are presented, which have been derived from a data taxonomy. The model is shown to accommodate a number of disparate variants, representing a range of interests in PSO study. It is demonstrated that, despite conceptual differences, there is much similarity amongst them. This has wide implications regarding the rigour of experimental practice, and validity of variant performance comparison.

behaviour, Coevolutionary systems which individuals evolved under an earlier independent evolutionary run can be potentially incorporated into a following GP run. To date, schemes for exploiting the RTL metaphor have emphasised syntactic over behavioural approaches. Thus, instructions are added to the later run such that the previous code can be explicitly indexed. In this work we demonstrate how the RTL concept is naturally supported by adopting a symbiotic framework for coevolution. Under the Pinball reinforcement learning task, we demonstrate how the initial RTL can be coevolved within a simpler formulation of the task and then used as the basis for providing solutions to a more difficult target task under the same domain. The resulting solutions are stronger than an RTL as coevolved against the target task alone or symbiosis as evolved without support for RTL.

complexity analysis, Self-adaptation in evolutionary computation lexical, categorical and syntactic evolutions, we explore the effect of power-law distributed social popularity on language origin and change. Simulation results reveal a critical scaling degree (lambda = 1.0) in power-law distributions that helps accelerate the diffusion of linguistic conventions and preserve high linguistic understandability in population. Other scaling degrees (lambda = 0.0 or lambda $>$ 1.0), however, tend to delay such diffusion process and affect linguistic understandability. Apart from the conventionalising nature of language communications in these models, increase in population size could also contribute to select the critical scaling degree, since this scaling degree can accommodate the influence of population size on linguistic understandability and many power-laws in real-world systems have their scaling degrees around this critical value.

Optimization Evolution strategies are known to lose their efficiency in problems with a large number of objective functions (the many-objective problem). This paper proposes an algorithm based on a stochastic differential equation approach combined with an evolutionary strategy. The proposed algorithm is intended to both allow the determination of tight Pareto-optimal solutions in many-objective problems (which is a difficult task for usual evolutionary algorithms) and to find a solution set that performs a relatively uniform sampling of the Pareto-optimal set (which is a deficiency of the known stochastic differential equation approach). The proposed algorithm is shown to attain such goals at a relatively low computational cost.

Problems: A comparative study metaheuristics with each other to enhance the search capabilities. It

can improve both of intensification and diversification toward the preferred solutions and concentrates the search efforts to investigate the promising regions in the search space. In this paper, a comparative study was developed to study the effect of the hybridisation of different metaheuristics within MOEA/D framework. We study four proposals of hybridisation, the first proposal is to combine adaptive discrete differential evolution operator with MOEA/D. The second one is to combine the path-Relinking operator with MOEA/D. the third and the fourth proposals combine both of them in MOEA/D. The comparative study uses a set of MOKSP instances commonly used in the literature to investigate the hybridisation effects as well as a set of quality assessment indicators. The experimental results indicate that the proposals are highly competitive for most test instances and can be considered as viable alternatives.

Algorithm for Community Detection analysis and data mining networks in recent years. Single-objective approaches which have only one optimization function (e.g., modularity or modularity density) may have weaknesses such as just a single community structure can be obtained or resolution limit. In this paper, a spectral clustering-based adaptive hybrid multi-objective harmony search algorithm (SCAH-MOHSA) combined with a local search strategy is proposed to detect the community structure in complex networks. At first, an improved spectral method is employed to convert the community detection problem into a data clustering issue while the length of the representation of a harmony in the harmony memory can be determined. Then, an adaptive hybrid multi-objective harmony search algorithm is used to solve the multi-objective optimization problem so as to resolve the community structure. The experiments on both synthetic and real world networks demonstrate our method achieves partition results which fit the real situation in an even better fashion.

Search heuristics. It aims to raise the level of generality of the algorithm to solve problems in different domains. In this paper we propose a hyper-heuristic based on Variable Neighbourhood Search (VNS), which consists of two main steps: shaking and local search. Shaking disturbs solutions, and then local search seeks for the local optima. In our algorithm, we propose a mechanism to adjust the computational budget of local search periodically based on the search status. We also use a dynamically-sized population to store good solutions during the search process. Performance of the proposed algorithm is compared with four benchmark algorithms by four kinds of problems, Max-SAT, bin packing, flow shop scheduling, and personnel scheduling. Our algorithm finds the best solutions for around 90percent of the tested instances.

Performance performance of a meta-hyper-heuristic algorithm, a hyper-heuristic which employs one or more metaheuristics as low-level heuristics. Alternative mechanisms for selecting the solutions to be refined further by means of local search, as well as the intensity of subsequent refinement in terms of number of allowable function evaluations, are investigated. Furthermore, defining a local search as one of the low-level heuristics versus applying the algorithm directly to the solution space is also investigated. Performance is evaluated on a diverse set of floating-point benchmark problems. The addition of local search was found to improve algorithm results significantly. Random selection of solutions for further refinement was identified as the best selection strategy and a higher intensity of refinement was identified as most desirable. Better results were obtained by applying the local search algorithm directly to the search space instead of defining it as a low-level heuristic.

Dynamic Multi-objective Job Shop Scheduling Problems hyper-heuristics, Evolutionary simulation-based optimization manufacturing system. However, the design of an effective SP is complicated and time-consuming due to the complexity of each scheduling decision as well as the interactions between these decisions. This paper proposes novel multi-objective genetic programming based hyper-heuristic methods for automatic design of SPs including dispatching rules (DRs) and due-date assignment rules (DDARs) in job shop environments. The experimental results show that the evolved Pareto front contains effective SPs that can dominate various SPs from combinations of existing DRs with dynamic and regression-based DDARs. The evolved SPs also show promising performance on unseen simulation scenarios with different shop settings. On the other hand, the proposed Diversified Multi-Objective Cooperative Coevolution (DMOCC) method can effectively evolve Pareto fronts of SPs compared to NSGA-II and SPEA2 while the uniformity of SPs obtained by DMOCC is better that those evolved by NSGA-II and SPEA2.

topology and its application to the multi-solution problems. First, we introduce a deterministic PSO characterised by normalised deterministic parameters and a canonical form system equation. This system is convenient to grasp effects of parameters on the stability. Second, we investigate effects of the average distance of several the swarm topologies on the search capability. Especially, we introduce

the switched topology where any information is not transmitted from the edge if the switch is off. Third, we consider an application to exploring multiple periodic points in simple dynamical systems. Performing numerical experiments for typical examples, the algorithm performance is investigated.

networks in recent years. In this study, we improve a recently proposed memetic algorithm for community detection in networks. By introducing a Population Generation via Label Propagation (PGLP) tactic, an Elitism Strategy (ES) and an Improved Simulated Annealing Combined Local Search (ISACLS) strategy, the improved memetic algorithm called (iMeme-Net) is put forward for solving community detection problems. Experiments on both computer-generated and real- world networks show the effectiveness and the multi-resolution ability of the proposed method.

multi-objective clustering ensemble algorithm (MOCLE), which is denoted as IMOCLE for short. First, we introduce a new clustering objective function to measure the individual difference in the optimization process so as to remain the diversity of the population. Then, a clustering ensemble technique is applied to MOCLE to obtain more competitive individual. The proposed algorithm can also ensure good partitions not be eliminated. The performance of the proposed algorithm has been compared with MOCLE over a suit of gene datasets. The experimental results show that, the superiority of the proposed method in terms of capability found the optimum number of clusters, and accuracy.

Algorithm processes of collective decision-making by bee colonies. The algorithm was designed with the objective of generating and maintaining diversity, promoting a multimodal search and obtaining multiple local optima without losing the ability of global optimization, thus representing an innovation compared with existent bee-inspired algorithms. It has been tested in five of the twenty-five minimisation problems proposed for the Optimization Competition of Real Parameters of the CEC 2005 Special Session on Real-Parameter Optimization, held in the 2005 IEEE Congress on Evolutionary Computation (CEC). The results obtained suggest the suitability of the algorithm to exploit multimodality of problems, being successful in the generation and maintenance of diversity and achieving good quality results in global optimization.

Characterization topographical features of the problem fitness landscape it is applied to. It is therefore of paramount importance to determine a set of features that is useful in order to choose an appropriate algorithm for a given problem. This way, the inefficient trial and error stage that most EA users carry out until they find an EA that satisfies their objectives can be reduced. In fact, as this, usually lengthy, trial and error stage is generally carried out in an ad hoc manner, the information the user gleans from the performance of the algorithms chosen and their particular parameter sets, or lack thereof, can be very misleading or plain useless. Thus, in previous work, we analyse a set of features in synthetic fitness landscapes that can be used in order to characterise problems and relate them to the performance of EAs. The objective is to define a mechanism to reduce the trial and error stage when choosing the correct EA and, at the same time, provide more in depth knowledge on the nature of the problem. Here, in order to highlight the usefulness of the approach, this analysis is extended to real world application landscapes by means of the characterisation of a horizontal axis wind turbine (HAWT) design problem, showing the relevance of the pre-processing stage in the selection of the most appropriate EA to solve it.

Handling Techniques Evolutionary simulation-based optimization constraint handling techniques have been developed to solve the constrained optimization problems which have attracted a lot of research interest. But it's still very difficult to decide when and how to use these algorithms and constraint handling techniques effectively. Some researchers have proposed some general frameworks like population-based algorithm portfolios (PAP), cooperative coevolving or ensemble strategies which use different subpopulations to run the algorithm parallel. These ideas don't consider the problems' characteristics in detail. Motivated by these observations, we propose a new method to construct the relationship between problems and algorithms as well as the constraint handling techniques standing the qualitative and quantitative point of view. This paper first summaries and extracts the problems' characteristics systematically, then combines different qualitative and quantitative methods in the Evolutionary Algorithms and constraint handling techniques respectively so as to get a reasonable correspondence. The experimental results confirm this relationship, which is valuable to guide future research.

Multi-Layered Networks Conflict of Interest Papers solving optimization problems of various complexity. Previous work in the optimization field on practical problems, using Cultural Algorithms, had shown that cultural learning emerged as the result of meta-level swarming of knowledge sources. This paper explores the use of meaningful neighbours in Cultural Algorithms for the constructed social metaphor.

The algorithm uses an enhanced multi-layer tactical restructuring to dynamically change the topology of agents in the formed networks, periodically during an algorithm run as a diversity preserving-measure. The approach has been applied to solve the set of real world problems proposed for the IEEE-CEC2011 evolutionary algorithm competition. Our results suggest that under appropriate parameter settings, the use of modified graphs of neighbourhoods with a probabilistic disruptive re-structuring of the topology produces better results on the considered test functions compared to the best known scores of other algorithms from the literature.

Optimization Problems using Cultural Algorithms Incorporating Swarm-Inspired Social Intelligence into Games the extent to which their organisational structure reflects the structures of the problems that are presented to them. In a recent study [14] used Cultural Algorithms as a framework in which to empirically address this and related questions. There, a problem generator based upon Langton's model of complexity was used to produce multi-dimensional real-valued problem landscapes of varying complexities. Various homogeneous social networks were then tested against the range of problems to see whether certain homogeneous networks were better at distributing problem solving knowledge from the Belief Space to individuals in the population.The experiments suggested that different network structures worked better in the distribution of knowledge for some optimization problems than others. If this is the case, then in a situation where several different problems are presented to a group, they may wish to use more than one network to solve them. In this paper, we investigate the advantages of using a heterogeneous network over a suite of different problem. We show that heterogeneous approaches begin to dominate homogeneous ones as the problem complexity increases.

expressed. In this study a simple regulatory mechanism is used to modify linear representations. The regulatory mechanism substantially enhances exploration at the expense of exploitation. For complex, polymodal fitness landscapes the modification yields a substantial improvement in performance. A negative control example demonstrates the technique yields a remarkable degradation in performance on a unimodal optimization problem designed to interact poorly with the technique. Analysis shows that the regulatory mechanism creates the potential for insertion and deletion mutations within the linear representation. These mutations have the effect of substantially increasing the number of genomes one mutation away from any given genome. This has the effect of decreasing the diameter of any search space where they regulatory technique is implemented.

numbers, favouring the development of data-parallel applications. Evolutionary algorithms are ideal for taking full advantage of SIMD (Single Instruction, Multiple Data) processing, which is available on both CPUs and GPUs. Creating software that runs on a GPU requires the use of specialised programming languages or styles, forcing practitioners to acquire new skills and limiting the portability of their developments. In this paper, we present an automatic translation from ESDL, a domain-specific language for composing evolutionary algorithms from arbitrary operators, to C++ AMP, a C++ extension for targeting heterogeneous hardware. Generating executable code from a simple platform-independent description allows practitioners with varying levels of programming expertise to take advantage of data-parallel execution, and enables those with strong expertise to further optimise their implementations. The automatic transformation is shown to produce code less optimal than a manual implementation but with significantly less developer effort. A secondary result is that GPU implementations require a large population, large individuals or an expensive evaluation function to achieve performance benefits over the CPU. All code developed for this paper is freely available online from http://stevedower.id.au/esdl/amp.

relationships that may exist between variables of a dataset. BN can be applied to data in in a variety of different ways. Yet, using a BN requires knowing its structure. BN structure learning represents a challenge as the number of possible structures is very large. Search and score approaches have been used to address the problem. One of them, a Genetic Algorithm based on the K2 search (K2GA) has shown that BNs can be learnt from many datasets. However, the computational cost which is involved is high while structures obtained from benchmark data often exhibit significant differences from known correct structures. In this paper, we investigate the use of K2GA within an Island Model (IM) implementation and compare the quality of the BN structures obtained with those of the traditional K2GA. Experiments are run on five datasets created from BNs with known structures. Results show that the use of IM improves the quality of the structures obtained. BNs present better fitnesses, but also sets of edges more consistent with the known true structures. We conclude that migration between islands helps maintaining diversity within each population.

Differential-Evolution-Based Memetic Algorithm problem of immense practical importance for

which exact solutions exist for very small problem sizes. This paper presents a new memetic algorithm, based on differential evolution, that solves routing problems of more than a thousand relay nodes; in comparison, the best-known approach in the literature handles up to 312 nodes. Simulation results show that the proposed method consistently produces better-quality solutions than three competing approaches.

Contact-Induced Vibration in HDD Servo Systems method to reject narrow-band disturbances in hard disk drive (HDD) servo systems. The parallel peak filter is introduced to provide high gain magnitude in the concerned frequency range of open-loop transfer function. Different from almost all the known peak filters, which possess second-order linear system structures, in this paper we explore how high-order peak filters can be designed to improve the loop shaping performance. The main idea is to replace some of the constant coefficients of common second-order peak filter by frequency-related transfer functions, and then genetic algorithm (GA) is adopted to perform optimal pole and zero placement for those transfer functions. Owing to the remarkable searching ability of GA, the expected shape of sensitivity function can be achieved by incorporating the resultant high- order peak filter in parallel with baseline feedback controller. As an application, a well designed seventh-order peak filter is used to compensate contact-induced vibration in a high density HDD servo system, where the benefits of high-order filter are clearly demonstrated.

formation of microstructure and development of strength. Manual derivation of cement hydration kinetic equation is very difficult because of the extreme complexity in Portland cement hydration. It can be reversely extracted automatically from the observed time series using evolutionary computation method. However, the physical meaning of coefficients of the extracted kinetic equation can not be understood easily, which limits the scope of application of kinetic equation in predicting hydration reaction. In this paper, in order to predict the reaction process of Portland cement, an evolutionary approach to predict the development of cement hydration using extreme early-age data and differential evolution algorithm is proposed. The experimental results indicate that the proposed method is very suitable for the forecasting of the development of degree of hydration for Portland cement.

applications is based on simulations. The quality of those simulations not only depends on the accuracy of the network model but also on the degree of reality of the underlying mobility model. VehILux a recently proposed vehicular mobility model, allows generating realistic mobility traces using traffic volume count data. It is based on the concept of probabilistic attraction points. However, this model does not address the question of how to select the best values of the probabilities associated with the points. Moreover, these values depend on the problem instance (i.e. geographical region). In this article we demonstrate how genetic algorithms (GAs) can be used to discover these probabilities. Our approach combined together with VehILux and a traffic simulator allows to generate realistic vehicular mobility traces for any region, for which traffic volume counts are available. The process of the discovery of the probabilities is represented as an optimisation problem. Three GAs—generational GA, steady-state GA, and cellular GA—are compared. Computational experiments demonstrate that using basic evolutionary heuristics for optimising VehILux parameters on a given problem instance permits to improve the model realism. However, in some cases, the results significantly deviate from real traffic count data. This is due to the route generation method of the VehILux model, which does not take into account specific behaviour of drivers in rush hours.

optimization. semiconductor chips. On these PCBs, there are various types of faults in the wiring. We must therefore test the PCBs to detect these faults, and it is essential to establish an efficient testing method. One type of test method uses two probes. Two probes, each touching one edge (end) of an inter-chip wiring, are used to check for the presence of faults. Testing is complete when we have confirmed that no faults exist on the PCB. The objective is to minimise the completion time for the testing, that is, our aim is to design efficient routes for the two probes; this is a two-probe routing problem. Several previous studies have proposed an approach involving a two-phase method. Although the two-phase method quickly finds a feasible solution, there is no guarantee that the solution is good. Besides, in recent years, PCB technology provides dense assembly capability and increased chip packaging; this implies that the scale of the two-probe routing problem becomes larger and the problem is difficult to be solved. We therefore propose a new approach, where we formulate a two-probe routing problem as a combinatorial optimization problem and then, we solve the combinatorial optimization problem by using genetic algorithm. We expect that our approach is useful for solving the large-scale problems. In computational experiments, we compare the results of our approach with those obtained using the two-phase method, and we show that our approach outperforms the two-phase method.

Discrete and combinatorial optimization. scheduling problem from the power industry, which we also make available online. The formulation of the problem and the suite are derived from real-world data collected recently. A first study of the landscape characteristics of these problem instances based on three different types of adaptive walk reveals a generally rugged landscape, with little global fitness-distance correlation. Initial results from a simple evolutionary algorithm shows indifferent performance compared to adaptive walks, suggesting that intensive local search may be an important component of a successful optimiser for this problem.

SynthesisA Multi-Objective Evolutionary Approach for Linear Antenna Array Design and Synthesis A Multi-Objective Evolutionary Approach for Linear Antenna Array Design and Synthesi Engineering applications electromagnetism. While designing a linear antenna array, the goal of the designer is to achieve the minimum average side lobe level and a null control in specific directions. In contrast to the existing methods that attempt to minimise a weighted sum of these two objectives considered here, in this paper our contribution is twofold. First, we have considered these as two distinct objectives which are optimised simultaneously in a multi-objective framework. Second, for directivity purposes, we have introduced another objective called the maximum side lobe level in the design formulation. The resulting multi-objective optimization problem is solved by using the recently-proposed decomposition-based Multi-Objective Particle Swarm Optimizer (dMOPSO). Our experimental results indicate that the proposed approach is able to obtain results which are better than those obtained by two other state-of- the-art Multi-Objective Evolutionary Algorithms (MOEAs). Additionally, the individual minima reached by dMOPSO outperform those achieved by two single- objective evolutionary algorithms.

Evolutionary Algorithms Memetic, multi-meme and hybrid algorithms (MOEAs) hybridised with mathematical programming techniques has significantly increased. However, most of these hybrid approaches are gradient-based, and tend to require a high number of extra objective function evaluations to estimate the gradient information required. The use of direct search methods i.e., methods that do not require gradient information has been, however, less popular in the specialised literature (although such approaches have been used with single-objective evolutionary algorithms). This paper precisely focuses on the design of a hybrid between the well-known MOEA/D and Nelder and Mead's algorithm. Clearly, the mathematical programming technique adopted here, acts as a local search mechanism, whose goal is to improve the search performed by MOEA/D. Because of its nature, the proposed local search mechanism can be easily coupled to any other decomposition-based MOEA. Our preliminary results indicate that this sort of hybridisation is quite promising for dealing with multi-objective optimization problems (MOPs) having high dimensionality (in decision variable space).

Brain-Computer Interfaces swarm optimization, Multi-objective evolutionary algorithms Interfaces (BCI) is introduced here. Continuous presentation in a projected two-dimensional space of the Electroencephalograph (EEG) cap is proposed. A multi-objective particle swarm optimization method (D^2MOPSO) is employed where particles move in the EEG cap space to locate the optimum set of solutions that minimise the number of selected channels and the classification error rate. This representation focuses on the local relationships among EEG channels as the physical location of the channels is explicitly represented in the search space avoiding picking up channels that are known to be uncorrelated with the mental task. In addition continuous presentation is a more natural way for problem solving in PSO framework. The method is validated on 10 subjects performing right-vs-left motor imagery BCI. The results are compared to these obtained using Sequential Floating Forward Search (SFFS) and shows significant enhancement in classification accuracy but most importantly in the distribution of the selected channels.

prediction from genomic data (IEEE-CEC), Estimation of distribution algorithms, Biometrics, bioinformatics and biomedical applications phenotypes is a common problem in genetic studies. In this paper we address the problem of determining the influence of gene joint expression in synapse predictability. The question is posed as an optimization problem in which the conditional entropy of gene subsets with respect to the synaptic connectivity phenotype is minimised. We investigate the use of single and multi-objective estimation of distribution algorithms and focus on real data from C. elegans synaptic connectivity. We show that the introduced algorithms are able to compute gene sets that allow an accurate synapse predictability. However, the multi-objective approach can simultaneously search for gene sets with different number of genes. Our results also indicate that optimization problems defined on constrained binary spaces remain challenging for the conception of competitive estimation of distribution algorithm.

for Cell Image Segmentation Problems Computation in Biomedical Engineering (IEEE-CEC),

Biometrics, bioinformatics and biomedical applications for supporting corneal regenerative medicine. Existing image analysis software requires knowledge about image processing of users because users have to combine several image processing on its analysis. Therefore, several types of methods to construct the objective image processing automatically using genetic programming (GP) have been proposed. However, in conventional researches, only canonical GP models were used. In this paper, GP models suited to cell image segmentation are investigated applying proposed controlling bloat model of GP. Applied models were six types in addition to the canonical model; those are Double Tournament, Tarpeian, Non-Destructive Crossover (NDC), Recombinative Hill-Climbing (RHC), Spatial Structure + Elitism (SS+E). The combination of image processing obtained by these GP models and the robustness are examined by comparative experiments, using corned endothelium cell image. The experiment results showed that SS+E is superior to other models in both robustness and image processing constructed for cell image segmentation, without depending on parameters of tree depth limit and penalty.

Image Analysis (IEEE-CEC), Computational Intelligence in Bioinformatics (IEEE-CEC) structure of an observation sequence. In this paper, HMM is used to provide the contextual information for detecting clinical signs present in diabetic retinopathy screen images. However, there is a need to determine a feature set that best represents the complexity of the data as well as determine an optimal HMM. This paper addresses these problems by automatically selecting the best feature set while evolving the structure and obtaining the parameters of a Hidden Markov Model. This novel algorithm not only selects the best feature set, but also identifies the topology of the HMM, the optimal number of states, as well as the initial transition probabilities.

Algorithm this paper a decentralized approach to calculate a charging schedule for electric vehicles based on a genetic algorithm is presented. It is predicted, that the number of battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) will increase to 5 million vehicles by the year of 2020. The increase of electric vehicles will have an impact on the existing power infrastructure, especially at specific times of day. Equipping all electric vehicles with a power controlling unit (PCU) in a so-called consumer grid, and connect the PCUs to each other, will allow to calculate an optimised schedule. This schedule ensures that all electric vehicles are charged and that a given maximum power peak will not be exceeded. First, the proposed approach was implemented in a Java program and its performance was evaluated for different scenarios. Afterwards, a VHDL (Very High Speed Integrated Circuit Hardware Description Language) implementation was created and verified by using simulation and FPGAs (Field Programmable Gate Array).

Algorithms Real-world applications (WLAN). This approach is based on a multiobjective genetic algorithm and greedy algorithms, and it is composed of two steps: network structure design and channel assignment. In the first step, the quantity, position and load balance of the access points are planned taking into account a minimum coverage level, the AP capacities and the traffic demand in the WLAN. In the second step, the channel of each access point is assigned in such a way that the network presents minimal interference and high throughput. The proposed algorithm delivers as the output an approximation of the set of efficient solutions. These solutions can be used to provide cost reduction and quality improvement on WLAN design. Results obtained by the proposed algorithm in two reasonable scenarios are presented in order to evaluate its efficiency.

applications not considered pure sinusoids due to the presence of, among others, the harmonic distortion. This work presents an approach based on the Particle Swarm Optimization (PSO) method for the harmonic component estimation in a PS. PSO is a technique of search/optimization that models the social behaviour observed in many species of birds, schooling fish and even human social behaviour. The technique uses a population of particles to search inside a multidimensional search space. The objective of the PSO is to adjust the speed and position of each particle, seeking for the best solution within the search space. The results demonstrate that the method can precisely identify the harmonic components in the distorted waveforms and it shows considerable advantages if compared to the most common algorithm for this purpose, the Discrete Fourier Transform.

Particle Swarm Optimization consider the multi-objective optimization problem of maximising the energy output under the consideration of wake effects and minimising the cost of the turbines and land area used for the wind farm. We present an efficient particle swarm optimization algorithm that computes a set of trade-off solutions for the given task. Our algorithm can be easily integrated into the layout process for developing wind farms and gives designers new insights into the trade-off between energy output and land area.

and a genetic algorithm optimization. dynamic ridesharing which could save travel cost and reduce

the environmental pollution. The ride matching problem with time windows in dynamic ridesharing considers matching drivers and riders with similar routes (with drivers detour flexibility) and time schedules on short notice. This problem is hard to solve. In this work, we model the ride matching problem with time windows in dynamic ridesharing as an optimization problem and propose a genetic algorithm to solve it. We consider minimising the total travel distance and time of the drivers (vehicles) and the total travel time of the riders and maximising the number of the matches. In addition, we provide datasets for the ride matching problem, derived from a real world travel survey for northeastern Illinois, to test the proposed algorithm. Experimentation results indicate that the idea of dynamic ridesharing is feasible and the proposed algorithm is able to solve the ridematching problem with time windows in reasonable time.

Grid and Micro-grids (IEEE-CEC), Evolutionary Computation for Intelligent Network Systems (CRO) algorithm to solve the optimal power flow (OPF) problem in power systems with the objective of minimising generation costs. Multiple constraints, such as the balance of the power, bus voltage magnitude limits, transmission line flow limits, transformer tap settings, etc., are considered. We adapt the CRO framework to the OPF problem by redesigning the elementary reaction operators. We perform simulations on the standard IEEE-14, -30, and -57 bus benchmark systems. We compare the perform of CRO with other reported evolutionary algorithms in the IEEE-30 test case. Simulation results show that CRO can obtain a solution with the lowest cost, when compared with other algorithms. To be more complete, we also give the average result for the IEEE-30 case, and the best and average results for the IEEE-14 and -57 test cases. The results given in this paper suggest that CRO is a better alternative for solving the OPF problem, as well as its variants for the future smart grid.

attracted much attention since there are a large number of application area in bioinformatics and social science. In this paper, we propose a novel Estimation of Distribution Algorithms which can effectively cope with graphs. The proposed method employs graph kernels in estimation and sampling phases in the EDAs. The preliminary experiments on edge-max problems and edge-min problems elucidate the effectiveness of the proposed method.

hyper-heuristics, Discrete and combinatorial optimization. of optimization algorithms across various classes of instances. Rather than reporting performance based on a chosen test set of benchmark instances, we aim to develop metrics for an algorithm's performance Generalized across a broader set of instances. Instances are summarised by a diverse set of features that correlate with difficulty, and we propose methods for visualising instances and algorithm performance in this high-dimensional feature space. The footprint of an algorithm is where good performance can be expected, and we propose new metrics to measure the relative size of an algorithm's footprint in instance space. The methodology is demonstrated using the Travelling Salesman Problem as a case study.

real-parameter optimization, is a recently introduced optimization algorithm which simulates the foraging behaviour of a bee colony. The proposed variant employs colony size (population size) reduction mechanism during the evolutionary process. Then modification is done to enhance the perturbation scheme. Further, in order to improve the population diversity and avoid the premature convergence, rank selection strategy is applied and analysed through simulation. The results show that the modified algorithm outperforms the basic ABC algorithm.

Fiber Optic Networks extensively used, because of its high cost. In order to evaluate the viability of such a costly investment, techno-economic models are employed. These models evaluate the investment from both technical (e.g., optimal network design) and economical (e.g., profitability) perspectives. However, an area that has not received much attention is the deployment plans of a given fibre optic investment. Existing works usually compare manually predefined deployment plans that are considered profitable, and then apply techno-economic analysis. While this indeed offers valuable information, it does not guarantee that the examined plans are the optimal ones. This should be considered as a major disadvantage, because there could be other deployment plans that could offer significantly higher profit. This paper offers a first attempt at looking for the optimal deployment plan of fibre optics, based on profit. Our method can be considered as a framework that wraps around existing techno-economic models. We employ a Genetic Algorithm (GA), which creates a population of deployment plans. These plans can then be evaluated through the usual techno-economic approach. The GA then evolves the population of these plans and at the end of the process acts as a decision support tool that advises on the optimal deployment plan, without the need for any human interference in the decision-making process. For comparison purposes, we compare the GA's results with results under other profitable plans. Results show that the introduction of the use of the GA is very advantageous and leads to a

significant increase in profit.

development of innovative multi-physics techniques has determined a growing interest towards modelling and optimization in engineering system design and green energy applications. In this context, advanced soft computing techniques can be applied by engineers to several problems and used within optimization process, in order to find out the best design and to improve the system performance. These techniques promise also to give new impulse to research on renewable systems and, especially in the last five year, on the so called Energy Harvesting Devices (EHDs). In this paper the optimization of a Tubular Permanent Magnet-Linear Generator for energy harvesting from traffic applications is presented. The optimization process is developed by means of hybrid evolutionary algorithms to reach the best overall system efficiency and the impact on the environment. Finally, an experimental validation of the designed EHD prototype is presented.

algorithms is essential. The agile team allocation is a NP-hard problem, since it comprises the allocation of self-organising and cross-functional teams. Many researchers have driven efforts to apply Computational Intelligence techniques to solve this problem. This work presents a hybrid approach based on NSGA-II multi-objective metaheuristic and Mamdani Fuzzy Inference Systems to solve the agile team allocation problem, together with an initial evaluation of its use in a real environment.

using Sectors Clipping and Similarities Transportation Management. Its main goal is to increase airspace capacity by reshaping, thus optimising, airspace sector boundaries based on the specifics of different air traffic situations, weather conditions and other factors. The primary objective for the optimization is to balance and reduce the workload of Air Traffic Controllers (ATCs). Many researchers have made efforts in this topic in the past years. However, air traffic changes continually, and DAS has to be adaptive to each change; be it in terms of aircraft density, dynamic routes, fleet mix, etc. Therefore, instead of sectorising the airspace each time a change occurs, we should re-sectorise it by maintaining maximum similarities between each sectorisation. In this paper, we propose a multi-objective evolutionary computation methodology to re-sectorise an airspace. We use a similarity measure between the existing sectorisation and the re-sectorisation as an objective to maximise during the evolution. We test the methodology with different air traffic conditions with four objective functions: minimise ATC task load standard deviation, maximise average flight sector time, maximise the minimum distance between traffic crossing points and sector boundaries, and maximise the similarity of two airspace factorisations. Experimental results show that our re-sectorisation method is able to perform airspace re-sectorisation under different changes in the air traffic, while satisfying the predefined objectives.

Problems, Memetic, multi-meme and hybrid algorithms, Discrete and combinatorial optimization. spatial resources of an institution to a set of entities by minimising the wastage of space and the violation of additional constraints. In this paper, an evolutionary local search algorithm is presented to tackle this problem. The evolutionary components of the algorithm include standard crossover and mutation operators and a relatively small population of individuals. The offspring produced by the evolutionary operators are subjected to a short but intense local search process. A very fast cost calculation method tailored for searching a large section of the search space is implemented. Extensive experimentation is carried out related to several parameters of the algorithm: the mutation rate, the population size, the length of the local search procedure after each mutation, hence the balance between the evolutionary and the local search stages, and the level of greediness of the local search process. The final results on 72 different data instances show that this hybrid evolutionary algorithm is very competitive with an integer programming model.

Teleoperation Robotics (IEEE-CEC), Evolutionary Computer Vision perform teleoperation of a mobile robot. Recently, the expectation to tele-operated mobile robots has been increasing much in order to perform a monitoring in various scenes. However, there are many critical problems in tele-operated systems. Especially, we must expand visual range from a robot, the usability of human interface, and intention sharing between the robot and operator. First, we discuss information visualisation for human friendly tele-operation. Next, we propose a tele-operating system based on multi-resolution map. Finally, we propose a method of 3D modelling using Microsoft Kinect sensor, and show several experimental results of the proposed method.

Attacks the form of a template) is stolen by a hacker as it is transmitted over a network and used by the hacker to impersonate the victim to gain unauthorised access. Biometric replay attacks can be particularly devastating because the victims of these attacks cannot easily alter their biometrics or the templates associated with their biometrics. In an effort to mitigate biometric replay attacks,

the authors of Previous research proposed two biometric authentication protocols. These protocols are based on two principles: (a) it is possible to evolve a set of distinct feature extractors (FEs) and (b) distinct FEs produce distinct templates. These principles gave rise to the concept of disposable FEs (and templates). In this paper, we introduce two additional protocols based on disposable FEs and templates. Our results show that these new protocols can be used more efficiently than the two proposed in previous research.

optimization., Heuristics, metaheuristics and hyper-heuristics problem with many real-world applications. Exact approaches are infeasible for solving large problem instances, due to the superpolynomial time complexity. Therefore, most solution approaches over the years have been metaheuristics, such as the Genetic Algorithm (GA). This paper presents a Hybrid GA, which incorporates problem-specific heuristics and domain knowledge into the algorithm. This causes the parameter settings to behave slightly different from regular GAs. To take care of the parametrisation, an additional GA is used, acting on the Hybrid GA. This will be referred to as the Meta-GA. In addition to solving all known problems optimally or within 1percent of the optimum, it manages to find a new best result within research literature for M-n200-k16, one of the largest problem instances.

(IEEE-CEC) In dealing with such data, we typically need to use methods like Principal Component Analysis and Projection Pursuit, to find interesting lower dimensional directions to project the data and hence reduce their dimensionality in a manageable size. In this work, we propose a new criterion of direction interestingness, which incorporates information from the density of the projected data. Subsequently, we use the Differential Evolution algorithm to perform optimization over the space of the projections and hence construct a new hierarchical clustering algorithmic scheme. The new algorithm shows promising performance over a series of real and simulated data.

systems, Evolutionary simulation-based optimization, Intelligent systems applications, Genetic Network Programming Programming (GNP) is good at generating action rules for multi-agent control in dynamic environments. However, some unimportant nodes exist in the program of GNP. These nodes serve as some redundant information which decreases the performance of GNP and the quality of the generated rules. In order to prune these nodes, this paper proposes a novel method named Credit GNP, where a credit branch is added to each node. When the credit branch is visited, the node is neglected and its function is not executed, so that the unimportant nodes could be jumped. The probability of visiting this credit branch and to which node it is jumped is determined by both evolution and Sarsa-learning, therefore, the unimportant nodes could be pruned automatically. Simulation results on the Tile-world problem show that the proposed method could get better programs and generate better and more general rules.

Co-authorship Networks analysis. Several approaches based on spectral partitioning and spectral clustering were used to detect structures in real world networks and databases. In this paper, we use the spectral partitioning to detect communities in a co-authorship network. The partitioning depends heavily on the weighting of the underlying network. We use an intuitive weighting scheme based on the ant colony optimization and show the communities found by spectral partitioning when using the ACO inspired weighting and when using trivial weighting based on the number of interactions between the authors.