EuroGP 2009 Wednesday 15 April

0830 **Registration Desk opens**

0930-0945 **Conference opening and announcements**

0945-1100 **Plenary session: Stuart R Hameroff MD**

1100-1130 **Coffee break**

1130-1300 **ALGORITHMS, POPULATIONS, and OPERATORS Chair: Michael O'Neill**

Automatic Creation of Taxonomies of Genetic Programming Systems ***Best Paper Nomination

Mario Graff, Riccardo Poli

A few attempts to create taxonomies in evolutionary computation have been made. These either group algorithms or group problems on the basis of their similarities. Similarity is typically evaluated by manually analysing algorithms/problems to identify key characteristics that are then used as a basis to form the groups of a taxonomy. This task is not only very tedious but it is also rather subjective. As a consequence the resulting taxonomies lack universality and are sometimes even questionable. In this paper we present a new and powerful approach to the construction of taxonomies and we apply it to Genetic Programming (GP). Only one manually constructed taxonomy of problems has been proposed in GP before, while no GP algorithm taxonomy has ever been suggested. Our approach is entirely automated and objective. We apply it to the problem of grouping GP systems with their associated parameter settings. We do this on the basis of performance signatures which represent the behaviour of each system across a class of problems. These signatures are obtained thorough a process which involves the instantiation of models of GP's performance. We test the method on a large class of Boolean induction problems.

The Role of Population Size in Rate of Evolution in Genetic Programming ***Best Paper Nomination

Ting Hu, Wolfgang Banzhaf

Population size is a critical parameter that affects the performance of an Evolutionary Computation model. A variable population size scheme is considered potentially beneficial to improve the quality of solutions and to accelerate fitness progression. In this contribution, we discuss the relationship between population size and the rate of evolution in Genetic Programming. We distinguish between the rate of fitness progression and the rate of genetic substitutions, which capture two different aspects of a GP evolutionary process. We suggest a new indicator for population size adjustment during an evolutionary process by measuring the rate of genetic substitutions. This provides a separate feedback channel for evolutionary process control, derived from concepts of population genetics. We observe that such a strategy can stabilize the rate of genetic substitutions and effectively accelerate fitness progression. A test with the Mackey-Glass time series prediction verifies our observations.

Genetic Programming Crossover: Does it Cross Over?

Colin Johnson

One justification for the use of crossover operators in Genetic Programming is that the crossover of program syntax gives rise to the crossover of information at the semantic level. In particular, a fitness-increasing crossover is presumed to act by combining fitness-contributing components of both parents. In this paper we investigate a particular interpretation of this hypothesis via an experimental study of 70 GP runs, in which we categorise each crossover event by its fitness properties and the information that contributes most strongly to those fitness properties. Some tentative evidence in support of the above hypothesis is extracted from this categorisation.

1300-1430 **Lunch**

1430-1600 **APPROACHES I Chair: Riccardo Poli**

One-Class Genetic Programming

Robert Curry, Malcolm Heywood

One-class classification naturally only provides one-class of exemplars, the target class, from which to construct the classification model. The one-class approach is constructed from artificial data combined with the known in-class exemplars. A multi-objective fitness function in combination with a local membership function is then used to encourage a co-operative coevolutionary decomposition of the original problem under a novelty detection model of classification. Learners are therefore associated with different subsets of the target class data and encouraged to tradeoff detection versus false positive performance; where this is equivalent to assessing the misclassification of artificial exemplars versus detection of subsets of the target class. Finally, the architecture makes extensive use of active learning to reinforce the scalability of the overall approach.

On Dynamical Genetic Programming: Random Boolean Networks in Learning Classifier Systems

Larry Bull, Richard Preen

Many representations have been presented to enable the effective evolution of computer programs. Turing was perhaps the first to present a general scheme by which to achieve this end. Significantly, Turing proposed a form of discrete dynamical system and yet dynamical representations remain almost unexplored within genetic programming. This paper presents results from an initial investigation into using a simple dynamical genetic programming representation within a Learning Classifier System. It is shown possible to evolve ensembles of dynamical Boolean function networks to solve versions of the well-known multiplexer problem. Both synchronous and asynchronous systems are considered.

Evolution of Search Algorithms Using Graph Structured Program Evolution

Shinichi Shirakawa, Tomoharu Nagao

Numerous evolutionary computation (EC) techniques and related improvements showing effectiveness in various problem domains have been proposed in recent studies. However, it is difficult to design effective search algorithms for given target problems. It is therefore essential to construct effective search algorithms automatically. In this paper, we propose a method for evolving search algorithms using Graph Structured Program Evolution (GRAPE), which has a graph structure and is one of the automatic programming techniques developed recently. We apply the proposed method to construct search algorithms for benchmark function optimization and template matching problems. Numerical experiments show that the constructed search algorithms are effective for utilized search spaces and also for several other search spaces.

1600-1620 **Coffee break**

1620-1750 **COEVOLUTION, GENERALISATION, and OPERATORS Chair: William B. Langdon**

Why coevolution doesn't "work": superiority and progress in coevolution ***Best Paper Nomination

Thomas Miconi

Coevolution often gives rise to counter-intuitive dynamics that defy our expectations. Here we suggest that much of the confusion surrounding coevolution results from imprecise notions of superiority and progress. In particular, we note that in the literature, three distinct notions of progress are implicitly lumped together: local progress (superior performance against current opponents), historical progress (superior performance against previous opponents) and global progress (superior performance against the entire opponent space). As a result, valid conditions for one type of progress are unduly assumed to lead to another. In particular, the confusion between historical and global progress is a case of a common error, namely using the training set as a test set. This error is prevalent among standard methods for coevolutionary analysis (CIAO, Master Tournament, Dominance Tournament, etc.) By clearly defining and distinguishing between different types of progress, we identify limitations with existing techniques and algorithms, address them, and generally facilitate discussion and understanding of coevolution. We conclude that the concepts proposed in this paper correspond to important aspects of the coevolutionary process.

On Improving Generalisation in Genetic Programming

Dan Costelloe, Conor Ryan

This paper is concerned with the generalisation performance of GP. We examine the generalisation of GP on some well-studied test problems and also critically examine the performance of some well known GP improvements from a generalisation perspective. From this, the need for GP practitioners to provide more accurate reports on the generalisation performance of their systems on problems studied is highlighted. Based on the results achieved, it is shown that improvements in training performance thanks to GP-enhancements represent only half of the battle.

A Rigorous Evaluation of Crossover and Mutation in Genetic Programming ***Best Paper Nomination

David White, Simon Poulding

The role of crossover and mutation in Genetic Programming (GP) has been the subject of much debate since the emergence of the field. In this paper, we contribute new empirical evidence to this argument using a rigorous and principled experimental method applied to six problems common in the GP literature. The approach tunes the algorithm parameters to enable a fair and objective comparison of two different GP algorithms, the first using a combination of crossover and reproduction, and secondly using a combination of mutation and reproduction. We find that crossover does not significantly outperform mutation on most of the problems examined. In addition, we demonstrate that the use of a straightforward Design of Experiments methodology is effective at tuning GP algorithm parameters.

1750-1930 **General poster sessions with conference reception**

Behavioural Diversity and Filtering in GP Navigation Problems

David Jackson

Promoting and maintaining diversity in a population is considered an important element of evolutionary computing systems, and genetic programming (GP) is no exception. Diversity metrics in GP are usually based on structural program characteristics, but even when based on behaviour they almost always relate to fitness. We deviate from this in two ways: firstly, by considering an alternative view of diversity based on the actual activity performed during execution, irrespective of fitness; and secondly, by examining the effects of applying associated diversity-enhancing algorithms to the initial population only. Used together with an extension to this approach that provides for additional filtering of candidate population members, the techniques offer significant performance improvements when applied to the Santa Fe artificial ant problem and a maze navigation problem.

A Real-Time Evolutionary Object Recognition System

Marc Ebner

We have created a real-time evolutionary object recognition system. Genetic Programming is used to automatically search the space of possible computer vision programs guided through user interaction. The user selects the object to be extracted with the mouse pointer and follows it over multiple frames of a video sequence. Several different alternative algorithms are evaluated in the background for each input image. Real-time performance is achieved through the use of the GPU for image processing operations.

On the Effectivity of Genetic Programming Compared to the Time-Consuming Full Search of Optimal 6-State Automata

Marcus Komann, Patrick Ediger, Dietmar Fey, Rolf Hoffmann

The Creature's Exploration Problem is defined for an independent agent on regular grids. This agent shall visit all non-blocked cells in the grid autonomously in shortest time. Such a creature is defined by a specific finite state machine. Literature shows that the optimal 6-state automaton has already been found by simulating all possible automata. This paper tries to answer the question if it is possible to find good or optimal automata by using evolution instead of time-consuming full simulation. We show that it is possible to achieve 80\% to 90\% of the quality of the best automata with evolution in much shorter time.

Semantic Aware Crossover for Genetic Programming: the case for real-valued function regression

Quang Uy Nguyen, Xuan Hoai Nguyen, Michael O'Neill

In this paper, we apply the ideas from [2] to investigate the effect of some semantic based guidance to the crossover operator of GP. We conduct a series of experiments on a family of real-valued symbolic regression problems, examining four different semantic aware crossover operators. One operator considers the semantics of the exchanged subtrees, while the other compares the semantics of the child trees to their parents. Two control operators are adopted which reverse the logic of the semantic equivalence test. The results show that on the family of test problems examined, the (approximate) semantic aware crossover operators can provide performance advantages over the standard subtree crossover adopted in Genetic Programming.

Beneficial Preadaptation in the Evolution of a 2D Agent Control System with Genetic Programming

Lee Graham, Rob Cattral, Franz Oppacher

We examine two versions of a genetic programming (GP) system for the evolution of a control system for a simple agent in a simulated 2D physical environment. Each version involves a complex behavior-learning task for the agent. In each case the performance of the GP system with and without initial epoch(s) of preadaptation are contrasted. The preadaptation epochs involve simplification of the learning task, allowing the evolved behavior to develop in stages, with rewards for intermediate steps. Both versions show an increase in mean best-of-run fitness when preadaptation is used.

New outcomes in Linear Genetic Programming: Adaptation, Performance and Vapnik-Chervonenkis Dimension of Straight Line Programs

José Luis Montana, Cesar Luis Alonso, Cruz Enrique Borges, Jose Luis Crespo

We discuss here empirical comparation between model selection methods based on Linear Genetic Programming. Two statistical methods are compared: model selection based on Empirical Risk Minimization (ERM) and model selection based on Structural Risk Minimization (SRM). For this purpose we have identified the main components which determine the capacity of some linear structures as classifiers showing an upper bound for the Vapnik-Chervonenkis (VC) dimension of classes of programs representing linear code defined by arithmetic computations and sign tests. This upper bound is used to define a fitness based on VC regularization that performs significantly better than the fitness based on empirical risk.

A Statistical Learning Perspective of Genetic Programming

Sylvain Gelly, Olivier Teytaud, Marc Schoenauer, Nicolas Bredèche, Merve Amil

This paper proposes a theoretical analysis of Genetic Programming (GP) from the perspective of statistical learning theory, a well grounded mathematical toolbox for machine learning. By computing the Vapnik-Chervonenkis dimension of the family of programs that can be inferred by a specific setting of GP, it is proved that a parsimonious fitness ensures universal consistency. This means that the empirical error minimization allows convergence to the best possible error when the number of test cases goes to infinity. However, it is also proved that the standard method consisting in putting a hard limit on the program size still results in programs of infinitely increasing size in function of their accuracy. It is also shown that cross-validation or hold-out for choosing the complexity level that optimizes the error rate in generalization also leads to bloat. So a more complicated modification of the fitness is proposed in order to avoid unnecessary bloat while nevertheless preserving universal consistency.

Quantum Circuit Synthesis with Adaptive Parameters Control

Cristian Ruican, Mihai Udrescu, Lucian Prodan, Mircea Vladutiu

The contribution presented herein proposes an adaptive genetic algorithm applied to quantum logic circuit synthesis that dynamically adjusts its control parameters. The adaptation is based on statistical data analysis for each genetic operator type, in order to offer the appropriate exploration at algorithm runtime without user intervention. The applied performance measurement attempts to highlight the ``good'' parameters and to introduce an intuitive meaning for the statistical results. The experimental results indicate an important synthesis runtime speedup. Moreover, while other GA approaches can only tackle the synthesis for quantum circuits over a small number of qubits, this algorithm can be employed for circuits that process up to 5-6 qubits.

Comparison of CGP and Age-Layered CGP Performance in Image Operator Evolution

Karel Slany

This paper analyses the efficiency of the Cartesian Genetic Programming (CGP) methodology in the image operator design problem at the functional level. The CGP algorithm is compared with an age layering enhancement of the CGP algorithm by the means of achieved best results and their computational effort. Experimental results show that the Age-Layreded Population Structure (ALPS) algorithm combined together with CGP can perform better in the task of image operator design in comparison with a common CGP algorithm.

0930-1100 **APPROACHES II Chair: Colin Johnson**

Memory with Memory in Tree-based Genetic Programming ***Best Paper Nomination

Riccardo Poli, Nicholas McPhee, Luca Citi, Ellery Crane

In recent work on linear register-based genetic programming (GP) we introduced the notion of Memory-with-Memory (MwM), where the results of operations are stored in registers using a form of soft assignment which blends a result into the current content of a register rather than entirely replace it. The MwM system yielded very promising results on a set of symbolic regression problems. In this paper, we propose a way of introducing MwM style behaviour in tree-based GP systems. The technique requires only very minor modifications to existing code, and, therefore, is easy to apply. Experiments on a variety of synthetic and real-world problems show that MwM is verybeneficial in tree-based~GP, too.

Tree based Differential Evolution

Christian Veenhuis

In recent years a new evolutionary algorithm for optimization in continuos spaces called Differential Evolution (DE) has developed. DE turns out to need only few evaluation steps to minimize a function. This makes it an interesting candidate for problem domains with high computational costs as for instance in the automatic generation of programs. In this paper a DE-based tree discovering algorithm called Tree based Differential Evolution (TreeDE) is presented. TreeDE maps full trees to vectors and represents discrete symbols by points in a real-valued vector space providing this way all arithmetical operations needed for the different DE schemes. Because TreeDE inherits the 'speed property' of DE, it needs only few evaluations to find suitable treeswhich produce comparable and better results as other methods.

Genetic Programming for Feature Subset Ranking in Binary Classification Problems

Kourosh Neshatian, Mengjie Zhang

We propose a genetic programming (GP) system for measuring the relevance of subsets of features in binary classification tasks. A virtual program structure and an evaluation function are defined in a way that constructed GP programs can measure the goodness of subsets of features. The proposed system can detect relevant subsets of features in different situations including multimodal class distributions and mutually correlated features where other ranking methods have difficulties. Our empirical results indicate that the proposed system is good at ranking subsets and giving insight into the actual classification performance. The proposed ranking system is also efficient in terms of feature selection.

1100-1130 **Coffee break**

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1130-1300 **Applications Chair: Wolfgang Banzhaf**

Genetic Programming Based Approach for Synchronization with Parameter Mismatches in EEG

Dilip Ahalpara, Siddharth Arora, M Santhanam

Effects of parameter mismatches in synchronized time series are studied first for an analytical non-linear dynamical system (coupled logistic map, CLM) and then in a realsystem (Electroencephalograph (EEG) signals). The internal system parameters derived from GP analysis are shown to be quite effective in understanding aspects of synchronization and non-synchronization in the two systems considered. In particular, GP is also successful in generating the CLM coupled equations to a very good accuracy with reasonable multi-step predictions. It is shown that synchronization in the abovetwo systems is well understood in terms of parameter mismatches in the system equations derived by GP approach.

Modeling Social Heterogeneity with Genetic Programming in an Artificial Double Auction Market

Shu-Heng Chen, Chung-Ching Tai

Individual differences in intellectual abilities can be observed across time and everywhere in the world, and this fact has been well studied by psychologists for a long time. To capture the innate heterogeneity of human intellectual abilities, this paper employs genetic programming as the algorithm of the learning agents, and then proposes the possibility of using population size as a proxy parameter of individual intelligence. By modeling individual intelligence in this way,we demonstrate not only a nearly positive relation between individual intelligence and performance, but more interestingly the effect of decreasing marginal contribution of IQ to performance found in psychological literature.

Exploring Grammatical Evolution for Horse Gait Optimisation

James Murphy, Michael O'Neill, Hamish Carr

Physics-based animal animations require data for realistic motion. This data is expensive to acquire through motion capture and inaccurate when estimated by an artist. Grammatical Evolution (GE) can be used to optimise pre-existing motion data or generate novel motions. Optimised motion data produces sustained locomotion in a physics-based model. To explore the use of GE for gait optimisation, the motion data of a walking horse, from a veterinary publication, is optimised for a physics-based horse model. The results of several grammars are presented and discussed. GE was found to be successful for optimising motion data using a grammar based on the concatenation of sinusoidal functions.

1300-1430 **Lunch**

1430-1600 **APPROACHES III Chair: : Ernesto Costa**

Self Modifying Cartesian Genetic Programming: Fibonacci, Squares, Regression and Summing ***Best Paper Nomination

Simon Harding, Julian Miller, Wolfgang Banzhaf

Self Modifying CGP (SMCGP) is a developmental form of Cartesian Genetic Programming(CGP). It is able to modify its own phenotype during execution of the evolved program. This is done by the inclusion of modification operators in the function set. Here we present the use of the technique on several different sequence generation and regression problems.

There is a Free Lunch for Hyper-Heuristics, Genetic Programming and Computer Scientists ***Best Paper Nomination

Riccardo Poli, Mario Graff

In this paper we prove that in some practical situations, there is a free lunch for hyper-heuristics, i.e., for search algorithms that search the space of solvers, searchers, meta-heuristics and heuristics for problems. This has consequences for the use of genetic programming as a method to discover new search algorithms and, more generally, problem solvers. Furthermore, it has also rather important philosophical consequences in relation to the efforts of computer scientists to discover useful novel search algorithms.

Extending Operator Equalisation: Fitness Based Self Adaptive Length Distribution for Bloat Free GP ***Best Paper Nomination

Sara Silva, Stephen Dignum

Operator equalisation is a recent bloat control technique that allows accurate control of the program length distribution during a GP run. By filtering which individuals are allowed in the population, it can easily bias the search towards smaller or larger programs. This technique achieved promising results with different predetermined target length distributions, using a conservative program length limit. Here we improve operator equalisation by giving it the ability to automatically determine and follow the ideal length distribution for each stage of the run, unconstrained by a fixed maximum limit. Results show that in most cases the new technique performs a more efficient search and effectively reduces bloat, by achieving better fitness and/or using smaller programs. The dynamics of the self adaptive length distributions are briefly analysed, and the overhead involved in following the target distribution is discussed, advancing simple ideas for improving the efficiency of this new technique.

1600-1615 **Coffee break**

1615-1745 **EuroGP Debate Chairs: Leonardo Vanneschi and Steve Gustafson**

1800-2300 **Local tour and Conference Dinner**

EuroGP 2009 Friday 17 April

0930-1100 **DATA MINING and OPERATORS Chair: Julian Miller**

Mining Evolving Learning Algorithms

Andras Joo

This paper presents an empirical method to identify salient patterns in tree based Genetic Programming. By using an algorithm derived from tree mining techniques and measuring the destructiveness of replacing patterns, we are able to identify those patterns that are responsible for the increased fitness of good individuals. The method is demonstraded on the evolution of learning rules for binary perceptrons.

On Crossover Success Rate in Genetic Programming with Offspring Selection

Gabriel Kronberger, Stephan Winkler, Michael Affenzeller, Stefan Wagner

A lot of progress towards a theoretic description of genetic programming in form of schema theorems has been made, but the internal dynamics and success factors of genetic programming are still not fully understood. In particular, the effects of different crossover operators in combination with offspring selection are still largely unknown. This contribution sheds light on the ability of well-known GP crossover operators to create better offspring (success rate) when applied to benchmark problems. We conclude that standard (sub-tree swapping) crossover is a good default choice in combination with offspring selection, and that GP with offspring selection and random selection of crossover operators does not improve the performance of the algorithm in terms of best solution quality or efficiency.

An experimental study on fitness distributions of tree shapes in GP with One-Point Crossover

César Estébanez, Ricardo Aler, José M. Valls, Pablo Alonso

In Genetic Programming (GP), One-Point Crossover is an alternative to the destructive properties and poor performance of Standard Crossover. One-Point Crossover acts in two phases, first making the population converge to a common tree shape, then looking for the best individual within that shape. So, we understand that One-Point Crossover is making an implicit evolution of tree shapes. We want to know if making this evolution explicit could lead to any improvement in the search power of GP. But we first need to define how this evolution could be performed. In this work we made an exhaustive study of fitness distributions of tree shapes for 6 different GP problems. We were able to identify common properties on distributions, and we propose a method to explicitly evaluate tree shapes. Based on this method, in the future, we want to implement a new genetic operator and a novel representation system for GP.

1100-1115 **Coffee break**

1115-1230 **Plenary session: Prof Dr Peter Schuster**

1230-1300 **Conference closing, announcements and conference/workshop awards**

EvoCOP 2009 Wednesday 15 April

0830 **Registration Desk opens**

0930-0945 **Conference opening and announcements**

0945-1100 **Plenary session: Stuart R Hameroff MD**

1100-1130 **Coffee break**

1130-1300 **Applications of Metaheuristics Chair: Peter Cowling**

A Tabu Search Algorithm with Direct Representation for Strip Packing

Jean-Philippe Hamiez, Julien Robet, Jin-Kao Hao

This paper introduces TSD, a new Tabu Search algorithm for a two-dimensional (2D) Strip Packing Problem (2D-SPP). TSD integrates several key features: A direct representation of the problem, a satisfaction-based solving scheme, two different complementary neighborhoods, a diversification mechanism and a particular tabu structure. The representation allows inexpensive basic operations. The solving scheme considers the 2D-SPP as a succession of satisfaction problems. The goal of the combination of two neighborhoods is (to try) to reduce the height of the packing while avoiding solutions with (hard to fill) tall and thin wasted spaces. Diversification relies on a set of historically ``interesting'' packings. The tabu structure avoids visiting similar packings. To assess the proposed TSD, experimental results are shown on a set of well-known benchmark instances and compared with previously reported tabu search algorithms as well as the best performing algorithms.

Finding Balanced Incomplete Block Designs with Metaheuristics

David Rodriguez Rueda, Carlos Cotta, Antonio J. Fernández

This paper deals with the generation of balanced incomplete block designs (BIBD), a hard constrained combinatorial problem with multiple applications. This problem is here formulated as a combinatorial optimization problem whose solutions are binary matrices. Two different neighborhood structures are defined, based on bit-flipping and position-swapping. These are used within three metaheuristic approaches, i.e., hill climbing, tabu search, and genetic algorithms. An extensive empirical evaluation is done using 86 different instances of the problem. The results indicate the superiority of the swap-based neighborhood, and the impressive performance of tabu search. This latter approach is capable of outperforming two techniques that had reported the best results in the literature (namely, a neural network with simulated annealing and a constraint local search algorithm).

An ACO approach to planning

Marco Baioletti, Alfredo Milani, Valentina Poggioni, Fabio Rossi

In this paper we describe a first attempt to solve planning problems through an Ant Colony Optimization approach. We have implemented an ACO algorithm, called ACOPlan, which is able to optimize the solutions of propositional planning problems, with respect to the plans length. Since planning is a hard computational problem, metaheuristics are suitable to find good solutions in a reasonable computation time. Preliminary experiments are very encouraging, because ACOPlan sometimes finds better solutions than state of art planning systems. Moreover, this algorithm seems to be easily extensible to other planning models.

EvoCOP 2009 Wednesday 15 April

1300-1430 **Lunch**

1430-1600 **Project/Workforce Scheduling Chair: Stefan Voss**

An Artificial Immune System for the Multi-Mode Resource-Constrained Project Scheduling Problem

Vincent Van Peteghem, Mario Vanhoucke

In this paper, an Artificial Immune System (AIS) for the multi-mode resource-constrained project scheduling problem (MRCPSP), in which multiple execution modes are available for each of the activities of the project, is presented. The AIS algorithm makes use of mechanisms which are inspired on the vertebrate immune system performed on an initial population set. This population set is generated with a controlled search method, based on experimental results which revealed a link between predefined profit values of a mode assignment and its makespan. The impact of the algorithmic parameters and the initial population generation method is observed and detailed comparative computational results for the MRCPSP are presented.

A genetic algorithm for net present value maximization for resource constrained projects

Mario Vanhoucke

In this paper, we present a new genetic algorithm for the resource-constrained project scheduling problem with discounted cash flows and investigate the trade-off between a project's net present value and its corresponding makespan. We consider a problem formulation where the pre-specified project deadline is not set as a hard constraint, but rather as a soft constraint that can be violated against a certain penalty cost. The genetic algorithm creates children from parents taken from three different populations, each containing relevant information about the (positive or negative) activity cash flows. We have tested various parent selection methods based on four crossover operators taken from literature and present extensive computational results.

Binary Exponential Back Off for Tabu Tenure in Hyperheuristics

Stephen Remde, Peter Cowling, Keshav Dahal, Nic Colledge

In this paper we propose a new tabu search hyperheuristic which makes individual low level heuristics tabu dynamically using an analogy with the Binary Exponential Back Off (BEBO) method used in network communication. We compare this method to a reduced Variable Neighbourhood Search (rVNS), greedy and random hyperheuristic approaches and other tabu search based heuristics for a complex real world workforce scheduling problem. Parallelisation is used to perform nearly 155 CPU-days of experiments. The results show that the new methods can produce results fitter than rVNS methods and within 99% of the fitness of those produced by a highly CPU-intensive greedy hyperheuristic in a fraction of the time.

1600-1620 **Coffee break**

1620-1750 **Real World Applications Chair: Peter Merz**

Staff Scheduling with Particle Swarm Optimisation and Evolution Strategies

Volker Nissen, Maik Guenther

The current paper uses a scenario from logistics to show that modern heuristics, and in particular particle swarm optimization (PSO)can significantly add to the improvement of staff scheduling in practice. Rapid, sub-daily planning, which is the focus of our research offers considerable productivity reserves for companies but also creates complex challenges for the planning software. Modifications of the traditional PSO method are required for a successful application to scheduling software. Results are compared to evolution strategies (ES).

University Course Timetabling with Genetic Algorithm: a Laboratory Excercises Case Study

Zlatko Bratkovic, Tomislav Herman, Vjera Omrcen, Marko Cupic, Domagoj Jakobovic

This paper describes the application of a hybrid genetic algorithm to a real-world instance of the university course timetabling problem. We address the timetabling of laboratory exercises in a highly constrained environment, for which a formal definition is given. Solution representation technique appropriate to the problem is defined, along with associated genetic operators and a local search algorithm. The approach presented in the paper has been successfully used for timetabling at the authors' institution and it was capable of generating timetables for complex problem instances.

Robustness Analysis in Evolutionary Multi-Objective Optimization Applied to VAR Planning in Electrical Distribution Networks

Carlos Barrico, Carlos Antunes, Dulce Pires

In this paper an approach to robustness analysis in evolutionary multi-objective optimization is applied to the problem of locating and sizing capacitors for reactive power compensation (VAR planning) in electric radial distribution networks. The main goal of this evolutionary algorithm is to find a non-dominated front containing the more robust non-dominated solutions also ensuring its diversity along the front. A concept of degree of robustness is incorporated into the evolutionary algorithm, which intervenes in the computation of the fitness value assigned to solutions. Two objective functions of technical and economical nature are explicitly considered in the mathematical model: minimization of system losses and minimization of capacitor installation costs. Constraints refer to quality of service, power flow, and technical requirements. It is assumed that some input data are subject to perturbations, both concerning the objective functions and the constraints coefficients.

1750-1930 **General EvoStar poster session**

EvoCOP 2009 Thursday 16 April

0930-1100 **Theoretical Developments Chair: Yuichi Nagata**

Metropolis and symmetric functions: a swan song

Lars Kaden, Karsten Weicker, Nicole Weicker

The class of symmetric functions is based on the OneMax function by a subsequent assigning application of a real valued function. In this work we derive a sharp boundary between those problem instances that are solvable in polynomial time by the Metropolis algorithm and those that need at least exponential time. This result is both proven theoretically and illustrated by experimental data. The classification of functions into easy and hard problem instances allows a deep insight into the problem solving power of the Metropolis algorithm and can be used in the process of selecting an optimization algorithm for a concrete problem instance.

Improving Performance in Combinatorial Optimisation Using Averaging and Clustering

Mohamed Qasem, Adam Prugel-Bennet

In a recent paper an algorithm for solving MAX-SAT was proposed which worked by clustering good solutions and restarting the search from the closest feasible solutions. This was shown to be an extremely effective search strategy, substantially out-performing traditional optimisation techniques. In this paper we extend those ideas to a second classic NP-Hard problem, namely Vertex Cover. Again the algorithm appears to provide an advantage over more established search algorithms, although it shows different characteristics to MAX-SAT. We argue this is due tothe different large-scale landscape structure of the two problems.

Exact solutions to the Traveling Salesperson Problem by a population-based evolutionary algorithm

Madeleine Theile

This articles introduces a $(\mu + 1)$-EA, for which is proven to be an exact {\it TSP} problem solver for a population of exponential size. We will show non-trivial upper bounds on the runtime until an optimum solution has been found. To the best of our knowledge this is the first time it has been shown that an $\mathcal{NP}$-hard problem is solved exactly instead of approximated only by a black box algorithm.

1100-1130 **Coffee break**

1130-1300 **Local Search Chair: Franz Rothlauf**

A Critical Event-Guided Perturbation Strategy for Iterated Local Search

Zhipeng Lu, Jin-Kao Hao

In this paper, we study the perturbation operator of Iterated Local Search. To guide more efficiently the search to move towards new promising regions of the search space, we introduce a Critical Element-Guided Perturbation strategy (CEGP). This perturbation approach consists of the identification of critical elements and then focusing on these critical elements within the perturbation operator. Computational experiments on two case studies---graph coloring and course timetabling---give evidence that this critical element-guided perturbation strategy helps reinforce the performance of Iterated Local Search.

Iterated Local Search for Minimum Power Symmetric Connectivity in Wireless Networks

Steffen Wolf, Peter Merz

The problem of finding a symmetric connectivity topology with minimum power consumption in a wireless ad-hoc network is NP-hard. This work presents a new iterated algorithm to solve this problem by combining filtering techniques with local search. The algorithm is benchmarked using instances with up to 1000 nodes, and results are compared to optimal or best known results as well as other heuristics. For these instances, the proposed algorithm is able to find optimal and near-optimal solutions and outperforms previous heuristics.

A New Binary Description of the Blocks Relocation Problem and Benefits in a Look Ahead Heuristic

Marco Caserta, Silvia Schwarze, Stefan Voss

We discuss the blocks relocation problem (BRP), a specific problem in storing and handling of uniform blocks like containers. The BRP arises as an important subproblem of major logistic processes, like container handling on ships or bays, or storing of palettes in a stacking area. Any solution method for the BRP has to work with the stacking area and needs to draw relevant information from there. The strength of related approaches may rely on the extensive search of neighborhood structures. For an efficient implementation, fast access to data of the current stacking area and an efficient transformation into neighboring states is needed. For this purpose, we develop a binary description of the stacking area that fulfills the aforementioned requirements. We implement the binary representation and use it within a look ahead heuristic. Comparing our results with those from literature, our method outperforms best known approaches in terms of solution quality and computational time.

1300-1430 **Lunch**

EvoCOP 2009 Thursday 16 April

1430-1600 **Hybrid Heuristics Chair: Jorge Tavares**

Beam-ACO Based On Stochastic Sampling for Makespan Optimization Concerning the TSP with Time Windows

Manuel López-Ibáñez, Christian Blum, Dhananjay Thiruvady, Andreas T. Ernst, Bernd Meyer

The travelling salesman problem with time windows is a difficult optimization problem that appears, for example, in logistics. Among the possible objective functions we chose the optimization of the makespan. For solving this problem we propose a so-called Beam-ACO algorithm, which is a hybrid method that combines ant colony optimization with beam search. In general, Beam-ACO algorithms heavily rely on accurate and computationally inexpensive bounding information for differentiating between partial solutions. In this work we use stochastic sampling as an alternative to bounding information. Our results clearly demonstrate that the proposed algorithm is currently a state-of-the-art method for the tackled problem.

A Hybrid Algorithm for Computing Tours in a Spare Parts Warehouse

Matthias Prandtstetter, Günther R. Raidl

We consider a real-world problem arising in a warehouse for spare parts. Items ordered by customers shall be collected and for this purpose our task is to determine efficient pickup tours within the warehouse. The algorithm we propose embeds a dynamic programming algorithm for computing individual optimal walks through the warehouse in a general variable neighborhood search (VNS) scheme. To enhance the performance of our approach we introduce a new self-adaptive variable neighborhood descent used as local improvement procedure within VNS. Experimental results indicate that our method provides valuable pickup plans, whereas the computation times are kept low and several constraints typically stated by spare parts suppliers are fulfilled.

Divide-And-Evolve Facing State-of-the-art Temporal Planners during the 6th International Planning

Jacques BIBAI, Marc SCHOENAUER, Pierre SAVEANT

Divide-and-Evolve(DAE) is the first evolutionary planner that has entered the biennial International Planning competition (IPC). Though the overall results were disappointing, a detailed investigation demonstrates that in spite of a harsh time constraint imposed by he competition rules, DAE was able to obtain the best quality results in a number of instances. Moreover, those results can be further improved by removing the time constraint, and correcting a problem due to completely random individuals. Room for further improvements are also explored.

1600-1615 **Coffee break**

EvoCOP 2009 Friday 17 April

0930-1100 **Best Paper Nominations Chair: Carlos Cotta**

Guided Ejection Search for the Job Shop Scheduling Problem ***Best Paper Nomination

Yuichi Nagata, Satoshi Tojo

We present a local search framework we term guided ejection search (GES) for solving the job shop scheduling problem (JSP). The main principle of GES is to always search for an incomplete solution from which some components are removed, subject to the constraint that a quality of the incomplete solution is better than that of the best (complete) solution found during the search. Moreover, the search is enhanced by a concept reminiscent of guided local search and problem-dependent local searches. The experimental results for the standard benchmarks for the JSP demonstrate that the suggested GES is robust and highly competitive with the state-of-the-art metaheuristics for the JSP.

Diversity Control and Multi-Parent Recombination for Evolutionary Graph Coloring Algorithms ***Best Paper Nomination

Daniel Cosmin Porumbel, Jin Kao Hao, Pascale Kuntz

We present a hybrid evolutionary algorithm for the graph coloring problem (Evocol). Evocol is based on two simple-but-effective ideas. First, we use an enhanced crossover that collects the \emph{best} color classes out of \emph{more than two} parents; the best color classes are selected using a ranking based on both class fitness and class size. We also introduce a simple method of using distances to assure the population diversity: at each operation that inserts an individual into the population or that eliminates an individual from the population, Evocol tries to maintain the distances between the remaining individuals as large as possible. The results of Evocol match the best-known results from the literature on almost all difficult Dimacs instances (a new solution is also reported for a very large graph). Evocol obtains these performances with a success rate of at least \%$.

A Plasmid Based Transgenetic Algorithm for the Biobjective Minimum Spanning Tree Problem ***Best Paper Nomination

Sílvia Monteiro, Elizabeth Goldbarg, Marco Goldbarg

This paper addresses the application of a plasmid based transgenetic algorithm to the biobjective spanning tree problem, an NP-hard problem with several applications in network design. The proposed evolutionary algorithm is inspired on two major evolutionary forces: the horizontal gene transfer and the endosymbiosis. The computational experiments compare the proposed approach to another transgenetic algorithm and to a GRASP algorithm proposed recently for the investigated problem. The comparison of the algorithms is done with basis on the binary additive e-indicator. The results show that the proposed algorithm consistently produces better solutions than the other methods.

1100-1115 **Coffee break**

1115-1230 **Plenary session: Prof Dr Peter Schuster**

1230-1300 **Conference closing, announcements and conference/workshop awards**

EvoBIO 2009 Wednesday 15 April

0830	**Registration Desk opens**
0930-0945	**Conference opening and announcements**
0945-1100	**Plenary session: Stuart R Hameroff MD**
1100-1130	**Coffee break**
1130-1300	**Other conference and workshop sessions**
1300-1430	**Lunch**
1430-1600	**Other conference and workshop sessions**
1600-1620	**Coffee break**
1620-1750	Genetics and Functional Genomics Chair: Marylyn Ritchie

Gaussian Graphical Models to Infer Putative Genes Involved in Nitrogen Catabolite Repression in S. cerevisiae

Kevin Kontos, Bruno André, Jacques van Helden, Gianluca Bontempi

Nitrogen is an essential nutrient for all life forms. Like most unicellular organisms, the yeast Saccharomyces cerevisiae transports and catabolizes good nitrogen sources in preference to poor ones. Nitrogen catabolite repression (NCR) refers to this selection mechanism. We propose an approach based on Gaussian graphical models (GGMs), which enable to distinguish direct from indirect interactions between genes, to identify putative NCR genes from putative NCR regulatory motifs and over-represented motifs in the upstream noncoding sequences of annotated NCR genes. Because of the high-dimensionalty of the data, we use a shrinkage estimator of the covariance matrix to infer the GGMs. We show that our approach makes significant and biologically valid predictions. We also show that GGMs are more effective than models that rely on measures of direct interactions between genes.

A Hierarchical Classification Ant Colony Algorithm for Predicting Gene Ontology Terms

Fernando Otero, Alex Freitas, Colin Johnson

This paper proposes a novel Ant Colony Optimisation algorithm for the hierarchical problem of predicting protein functions using the Gene Ontology (GO). The GO structure represents a challenging case of hierarchical
classification, since its terms are organised in a direct acyclic graph fashion where a term can have more than one parent - in contrast to only one parent in tree structures. The proposed method discovers an ordered list of classification rules which is able to predict all GO terms independently of their level. We have compared the proposed method against a baseline method, which consists of training classifiers for each GO terms individually, in five different ion-channel data sets and the results obtained are promising.

Conquering the Needle-in-a-Haystack: How Correlated Input Variables Beneficially Alter the Fitness Landscape for Neural Networks

Stephen D. Turner, Marylyn D. Ritchie, William S. Bush

Evolutionary algorithms such as genetic programming and grammatical evolution have been used for simultaneously optimizing network architecture, variable selection, and weights for artificial neural networks. Using an evolutionary algorithm to perform variable selection while searching for non-linear interactions is akin to searching for a needle in a haystack. There is, however, a considerable amount of correlation among variables in biological datasets, such as in microarray or genetic studies. Using the XOR problem, we show that correlation between non-functional and functional variables alters the variable selection fitness landscape by broadening the fitness peak over a wider range of potential input variables. Furthermore, when sub-optimal weights are used, local optima in the variable selection fitness landscape appear centered on each of the two functional variables. These attributes of the fitness landscape may supply building blocks for evolutionary search procedures, and may provide a rationale for conducting a local search for variable selection.

1750-1930 **General poster sessions with conference reception**

EvoBIO 2009 Thursday 16 April

0930-1100 **Network Analysis I Chair: Clara Pizzuti**

A Comparison of Genetic Algorithms and Particle Swarm Optimization for Parameter Estimation in Stochastic Biochemical Systems

Daniela Besozzi, Paolo Cazzaniga, Giancarlo Mauri, Dario Pescini, Leonardo Vanneschi

The modelling of biochemical systems requires the knowledge of several quantitative parameters (e.g. reaction rates) which are often hard to measure in laboratory experiments. Furthermore, when the system involves small numbers of molecules, the modelling approach should also take into account the effects of randomness on the system dynamics. In this paper, we tackle the problem of estimating the unknown parameters of stochastic biochemical systems by means of two optimization heuristics, genetic algorithms and particle swarm optimization. Their performances are tested and compared on two basic kinetics schemes: the Michaelis-Menten equation and the Brussellator. The experimental results suggest that particle swarm optimization is a suitable method for this problem. The set of parameters estimated by particle swarm optimization allows us to reliably reconstruct the dynamics of the Michaelis-Menten system and of the Brussellator in the oscillating regime.

Optimal Use of Expert Knowledge in Ant Colony Optimization for the Analysis of Epistasis in Human Disease ***Best Paper Nomination

Casey Greene, Jason Gilmore, Jeff Kiralis, Peter Andrews, Jason Moore

The availability of chip-based technology has transformed human genetics and made routine the measurement of thousands of DNA sequence variations giving rise to an informatics challenge. This challenge is the identification of combinations of interacting DNA sequence variations predictive of common diseases. We have previously developed Multifactor Dimensionality Reduction (MDR), a method capable of detecting these interactions, but an exhaustive MDR analysis is exponential in time complexity and thus unsuitable for an interaction analysis of genome-wide datasets. Therefore we look to stochastic search approaches to find a suitable wrapper for the analysis of these data. We have previously shown that an ant colony optimization (ACO) framework can be successfully applied to human genetics when expert knowledge is included. We have integrated an ACO stochastic search wrapper into the open source MDR software package. In this wrapper we also introduce a scaling method based on an exponential distribution function with a single user-adjustable parameter. Here we obtain expert knowledge from Tuned ReliefF (TuRF), a method capable of detecting attribute interactions in the absence of main effects, and perform a power analysis at different parameter settings. We show that the expert knowledge distribution parameter, the retention factor, and the weighting of expert knowledge significantly affect the power of the method.

On the Efficiency of Local Search Methods for the Molecular Docking Problem ***Best Paper Nomination

Jorge Tavares, Salma Mesmoudi, El-Ghazali Talbi

Evolutionary approaches to molecular docking typically hybridize with local search methods, more specifically, the Solis-Wet method. However, some studies indicated that local search methods might not be very helpful in the context of molecular docking. An evolutionary algorithm with proper genetic operators can perform equally well or even outperform hybrid evolutionary approaches. We show that this is dependent on the type of local search method. We also propose an evolutionary algorithm which uses the L-BFGS method as local search. Results demonstrate that this hybrid evolutionary outperforms previous approaches and is better suited to serve as a basis for evolutionary docking methods.

1100-1130 Coffee break

1130-1300 **Network Analysis II Chair: Marylyn Ritchie**

Clustering Metagenome Short Reads using Weighted Proteins ***Best Paper Nomination

Gialuigi Folino, Fabio Gori, Mike S.M. Jetten, Elena Marchiori

This paper proposes a new knowledge-based method for clustering metagenome short reads. The method incorporates biological knowledge in the clustering process, by means of a list of proteins associated to each read. These proteins are chosen from a reference proteome database according to their similarity with the given read, as evaluated by BLAST. We introduce a scoring function for weighting the resulting proteins and use them for clustering reads. The resulting clustering algorithm performs automatic selection of the number of clusters, and generates possibly overlapping clusters of reads. Experiments on real-life benchmark datasets show the effectiveness of the method for reducing the size of a metagenome dataset while maintaining a high accuracy of organism content.

Validation of a morphogenesis model of Drosophila early development by a multi-objective evolutionary optimization algorithm ***Best Paper Nomination

Rui Dilão, Daniele Muraro, Miguel Nicolau, Marc Schoenauer

We apply evolutionary computation to calibrate the parameters of a morphogenesis model of Drosophila early development. The model aims to describe the establishment of the steady gradients of Bicoid and Caudal proteins along the antero-posterior axis of the embryo of Drosophila. The model equations consist of a system of non-linear parabolic partial differential equations with initial and zero flux boundary conditions. We compare the results of single-and multi-objective variants of the CMA-ES algorithm for the model the calibration with the experimental data. Whereas the multi-objective algorithm computes a full approximation of the Pareto front, repeated runs of the single-objective algorithm give solutions that dominate (in the Pareto sense) the results of the multi-objective approach. We retain as best solutions those found by the latter technique. From the biological point of view, all such solutions are all equally acceptable, and for our test cases, the relative error between the experimental data and validated model solutions on the Pareto front are in the range 3%-6%. This technique is general and can be used as a generic tool for parameter calibration problems.

Evolutionary Approaches for Strain Optimization using Dynamic Models under a Metabolic Engineering Perspective

Pedro Evangelista, Isabel Rocha, Eugénio C. Ferreira, Miguel Rocha

One of the purposes of Systems Biology is the quantitative modeling of biochemical networks. In this effort, the use of dynamical mathematical models provides for powerful tools in the prediction of the phenotypical behavior of microorganisms under distinct environmental conditions or subject to genetic modifications. The purpose of the present study is to explore a computational environment where dynamical models are used to support simulation and optimization tasks. These will be used to study the effects of two distinct types of modifications over metabolic models: deleting a few reactions knockouts) and changing the values of reaction kinetic parameters. In the former case, we aim to reach an optimal knockout set, under a defined objective function. In the latter, the same objective function is used, but the aim is to optimize the values of certain enzymatic kinetic coefficients. In both cases, we seek for the best model modifications that might lead to a desired impact on the concentration of chemical species in a metabolic pathway. This concept was tested by trying to maximize the production of dihydroxyacetone phosphate, using Evolutionary Computation approaches. As a case study, the central carbon metabolism of Escherichia coli is considered. A dynamical model based on ordinary differential equations is used to perform the simulations. The results validate the main features of the approach.

1300-1430 **Lunch**

1430-1600 **Microarray Analysis, Evolution, and Phylogenetics I Chair: Elena Marchiori**

F-score with Pareto Front Analysis for Multiclass Gene Selection

Piyushkumar A. Mundra, Jagath C. Rajapakse

F-score is a widely used filter criteria for gene selection in multiclass cancer classification. This ranking criterion may become biased towards classes that have surplus of between-class sum of squares, resulting in inferior classification performance. To alleviate this problem, we propose to compute individual class wise between-class sum of squares with Pareto frontal analysis to rank genes. We tested our approach on four multiclass cancer gene expression datasets and the results show improvement in classification performance.

Association Study between Gene Expression and Multiple Relevant Phenotypes with Cluster Analysis

Zhenyu Jia, Yipeng Wang, Kai Ye, Qilan Li, Sha Tang, Shizhong Xu, Dan Mercola

A complex disease is usually characterized by a few relevant disease phenotypes which are dictated by complex genetical factors through different biological pathways. These pathways are very likely to overlap and interact with one another leading to a more intricate network. Identification of genes that are associated with these phenotypes will help understand the mechanism of the disease development in a comprehensive manner. However, no analytical model has been reported to deal with multiple phenotypes simultaneously in gene-phenotyp association study. Typically, a phenotype is inquired at one time. The conclusion is then made simply by fusing the results from individual analysis based on single phenotype. We believe that the certain information among phenotypes may be lost by not analyzing the phenotypes jointly. In current study, we proposed to investigate the associations between expressed genes and multiple phenotypes with a single statisti model. The relationship between gene expression level and phenotypes is described by a multiple linear regression equation. Each regressior coefficient, representing gene-phenotype(s) association strength, is assumed to be sampled from a mixture of two normal distributions. The two normal components are used to model the behaviors of phenotype(s)-relevant genes and phenotype(s)-irrelevant genes, respectively. Th conclusive classification of coefficients determines the association status between genes and phenotypes. .

Refining Genetic Algorithm based Fuzzy Clustering through Supervised Learning for Unsupervised Cancer Classification

Anirban Mukhopadhyay, Ujjwal Maulik, Sanghamitra Bandyopadhyay

Fuzzy clustering is an important tool for analyzing microarray cancer data sets in order classify the tissue samples. This article describes a real-coded Genetic Algorithm (GA) based fuzzy clustering method that combineswith popularArtificialNeuralNetwork (ANN) / Support vector Machine (SVM) based classifier in this purpose. The clustering produced by GA is refined using ANN / SVM classifier to obtain improved clustering performance. The proposed technique is used to cluster three publicly available real life microarray cancer data sets. The performance of the proposed clustering method has been compared to several other microarray clustering algorithms for three publicly available benchmark cancer data sets, viz., leukemia, Colon cancer and Lymphoma data to establish its superiority.

1600-1615 **Coffee break**

1615-1745 **Microarray Analysis, Evolution, and Phylogenetics II**

Microarray Biclustering: a novel Memetic Approach based on the PISA Platform

Cristian Gallo, Jessica Carballido, Ignacio Ponzoni

In this paper, a new memetic approach that integrates a Multi-Objective Evolutionary Algorithm (MOEA) with local search for microarray biclustering is presented. The original features of this proposal are the consideration of opposite regulation and incorporation of a mechanism for tuning the balance between the size and row variance of the biclusters. The approach was developed according to the Platform and Programming Language Independent Interface for Search Algorithms (PISA) framework, thus achieving the possibility of testing and comparing several different memetic MOEAs. The performance of the MOEA strategy based on the SPEA2 performed better, and its resulting biclusters were compared with those obtained by a multi-objective approach recently published. The benchmarks were two datasets corresponding to Saccharomyces cerevisiae and human B-cells Lymphoma. Our proposal achieves a better proportion of coverage of the gene expression data matrix, and it also obtains biclusters with new features that the former existing evolutionary strategies can not detect.

Simulating Evolution of Drosophila melanogaster Ebony Mutants Using a Genetic Algorithm

Glennie Helles

Genetic algorithms are generally quite easy to understand and work with, and they are a popular choice in many cases. One area in which genetic algorithms are widely and successfully used is artificial life where they are used to simulate evolution of artificial creatures. However, despite their suggestive name, simplicity and popularity in artificial life, they do not seem to have gained a footing within the field of population genetics to simulate evolution of real organisms -- possibly because genetic algorithms are based on a rather crude simplification of the evolutionary mechanisms known today. However, in this paper we report how a standard genetic algorithm is used to successfully simulate evolution of ebony mutants in a population of Drosophila melanogaster (D.melanogaster). The results show a remarkable resemblance to the evolution observed in real biological experiments with ebony mutants, indicating that despite the simplifications, even a simple standard genetic algorithm does indeed capture the governing principles in evolution, and could be used beneficially in population genetics studies.

A Memetic Algorithm for Phylogenetic Reconstruction with Maximum Parsimony

Jean-Michel Richer, Adrien Goeffon, Jin-Kao Hao

The Maximum Parsimony problem aims at reconstructing a phylogenetic tree from DNA, RNA or protein sequences while minimizing the number of evolutionary changes. Much work has been devoted by the research community to solve this NP-complete problem and many algorithms and techniques have been devised in order to find high quality solutions with reasonable computational resources. In this paper we present a memetic algorithm (implemented in the software Hydra) which is based on an integration of an effective local search operator with a specific topological tree crossover operator. We report computational results of Hydra on a set of 12 benchmark instances from the literature and demonstrate its effectiveness with respect to one of the most powerful software (TNT). We also study the behavior of the algorithm with respect to some fundamental ingredients.

1800-2300 **Social Trip followed by Conference Dinner**

0930-1100 **Proteomics and Biomedical Classification Chair: Jorge Tavares**

Guidelines to Select Machine Learning Scheme for Classification of Biomedical Datasets

Ajay Tanwani, Jamal Afridi, Zubair Shafiq, Muddassar Farooq

Biomedical datasets pose a unique challenge to machine learning and data mining algorithms for classification because of their high dimensionality, multiple classes, noisy data and missing values. This paper provides a comprehensive evaluation of a set of diverse machine learning schemes on a number of biomedical datasets. To this end, we follow a four step evaluation methodology: (1) pre-processing the datasets to remove any redundancy, (2) classification of the datasets using six different machine learning algorithms; Naive Bayes (probabilistic), multi-layer perceptron (neural network), SMO (support vector machine), IBk (instance based learner), J48 (decision tree) and RIPPER (rule-based induction), (3) bagging and boosting each algorithm, and (4) combining the best version of each of the base classifiers to make a team of classifiers with stacking and voting techniques. Using this methodology, we have performed experiments on 31 different biomedical datasets. To the best of our knowledge, this is the first study in which such a diverse set of machine learning algorithms are evaluated on so many biomedical datasets. The important outcome of our extensive study is a set of promising guidelines which will help researchers in choosing the best classification scheme for a particular nature of biomedical dataset.

Chronic Rat Toxicity Prediction of Chemical Compounds using Kernel Machines

Georg Hinselmann, Andreas Jahn, Nikolas Fechner, Andreas Zell

A recently published study showed the feasibility of chronic rat toxicity prediction, an important task to reduce the number of animal experiments using the knowledge of previous experiments. We benchmarked various kernel learning approaches for the prediction of chronic toxicity on a set of 565 chemical compounds, labeled with the Lowest Observed Adverse Effect Level, and achieved a prediction error close to the interlaboratory reproducibility. epsilon-Support Vector Regression was used in combination with numerical molecular descriptors and the Radial Basis Function Kernel, as well as with graph kernels for molecular graphs, to train the models. The results show that a kernel approach improves the Mean Squared Error and the Squared Correlation Coefficient using leave-one-out cross-validation and a seeded 10-fold-cross-validation averaged over 10 runs. Compared to the state-of-the-art, the Mean Squared Error was improved up to MSEloo of 0.45 and MSEcv of 0.46 ± 0.09, which is close to the theoretical limit of the estimated interlaboratory reproducibility of 0.41. The Squared Empirical Correlation Coefficient was improved to Q2loo of 0.58 and Q2cv of 0.57 ± 0.10. The results show that numerical kernels and graph kernels are both suited for predicting chronic rat toxicity for unlabeled compounds.

1100-1115 **Coffee break**

1115-1230 **Plenary session: Prof Dr Peter Schuster**

1230-1300 **Conference closing, announcements and conference/workshop awards**

EvoCOMNET 2009 Wednesday 15 April

0830 **Registration Desk opens**

0930-0945 **Conference opening and announcements**

0945-1100 **Plenary session: Stuart R Hameroff MD**

1100-1130 **Coffee break**

1130-1300 **Session 1 Chair: Gianni Di Caro**

Location Discovery in Wireless Sensor Networks Using a Two-Stage Simulated Annealing ***Best Paper Nomination

Guillermo Molina, Enrique Alba

Wireless Sensor Networks (WSN) monitor the physical world using small wireless devices known as sensor nodes. Location information plays a critical role in many of the applications where WSN are used. A widely used self-locating mechanism consists in equipping a small subset of the nodes with GPS hardware, while the rest of the nodes employ reference estimations (received signal strength, time of arrival, etc.) in order to determine their locations. Finding the location of nodes using node-to-node distances combined with a set of known node locations is referred to as Location Discovery (LD). The main di?culty found in LD is the presence of measurement errors, which results in location errors. We describe in this work an error model for the estimations, propose
a two-stage Simulated Annealing to solve the LD problem using this model, and discuss the results obtained. We will put a special stress on the improvements obtained by using our proposed technique.

Extremal Optimization as a Viable Means for Mapping in Grids

Ivanoe De Falco, Antonio Della Cioppa, Domenico Maisto, Umberto Scafuri, Ernesto Tarantino

An innovative strategy, based on Extremal Optimization, to map the tasks making up a user application in grid environments is proposed. Differently from other evolutionary-based methods which simply search for one site onto which deploy the application, our method deals with a multisite approach. Moreover, we consider the nodes composing the sites as the lowest computational units and we take into account their actual loads. The proposed approach is tested on a group of different simulations representing a set of typical real-time situations.

An Evolutionary Algorithm for Survivable Virtual Topology Mapping in Optical WDM Networks ***Best Paper Nomination

Fatma Corut Ergin, Aysegul Yayimli, Sima Uyar

The high capacity of fibers used in optical networks, can be divided into many channels, using the WDM technology. Any damage to a fiber causes all the channels routed through this link to be broken, which may result in a serious amount of data loss. As a solution to this problem, the virtual layer can be mapped onto the physical topology, such that, a failure on any physical link does not disconnect the virtual topology. This is known as the survivable virtual topology mapping problem. In this study, our aim is to design an efficient evolutionary algorithm to find a survivable mapping of a given virtual topology while minimizing the resource usage. We develop and experiment with different evolutionary algorithm components. As a result, we propose a suitable evolutionary algorithm and show that it can be successfully used for this problem. Overall, the results are promising and promote further study.

1300-1430 **Lunch**

1430-1600 **Session 2 Chair: Gianni Di Caro**

A Framework for Evolutionary Peer-to-Peer Overlay Schemes ***Best Paper Nomination

Michele Amoretti

In the last half-decade, many considerable peer-to-peer protocols have been proposed. They can be grouped in few architectural models, taking into account basically two dimensions: the dispersion degree of information about shared resources (centralized, decentralized, hybrid), and the logical organization (unstructured, structured). On the other side, there is a lack of common understanding about adaptive peer-to-peer sytems. In our view, peers' internal structure may change in order to adapt to the environment, according to an adaptation plan. To formalize this approach, we propose the Adaptive Evolutionary Framework (AEF). Moreover, we apply it to the problem of sharing consumable resources, such as CPU, RAM, and disk space.

Wireless Communications for Navigation in Robot Swarms

Gianni A. Di Caro, Frederick Ducatelle, Luca Gambardella

We consider a swarm of robots equipped with an infrared range and bearing device (Ir-RB) which is able both to make estimates of the relative distance and angle between two robots in line-of-sight (LoS) and to transfer data between them. Through the Ir-RB, the robots create a LoS mobile ad hoc network (LoS MANET). We investigate different ways to implement a swarm-level distributed navigation function exploiting the routing information gathered within the LoS MANET. In the scenario we consider, a number of different events present themselves in different locations. To be serviced, each event needs that a robot with the appropriate skills is gathered at its location. We present two swarm-level solutions for guiding the navigation of the selected robots towards the events. Both solutions exploit the Ir-RB device, that allows to relate links in the LoS MANET to relative geographic information. We use a bio-inspired ad hoc network routing protocol to dynamically find and maintain paths between a robot and an event location in the LoS MANET, and use them to guide the robot to its goal. The performance of the two approaches is studied in a number of network scenarios presenting different density, mobility, and bandwidth availability.

1600-1620 **Coffee break**

1620-1750 **Session 3 Chair: Gianni Di Caro**

Multiuser Scheduling in HSDPA with Particle Swarm Optimization

Mehmet E. Aydin, Raymond Kwan, Cyril Leung, Jie Zhang

In this paper, a mathematical model of multiuser scheduling problem in HSDPA is developed to use in optimization process. A more realistic imperfect channel state information (CSI) feedback, which is required for this problem, in the form of a finite set of Channel Quality Indicator (CQI) values is assumed, as specified in the HSDPA standard [1]. A global optimal approach and a particle swarm optimization approach are used to solve the problem. Simulation results indicate that the performances of the two approaches are very close even though the complexity of the particle swarm optimization approach is much lower.

Web Application Security Through Gene Expression Programming

Jaroslaw Skaruz, Franciszek Seredynski

In the paper we present a novel approach based on applying a modern metaheuristic Gene Expression Programming (GEP) to detecting web application attacks. This class of attacks relates to malicious activity of an intruder against applications, which use a database for storing data. The application uses SQL to retrieve data from the database and web server mechanisms to put them in a web browser. A poor implementation allows an attacker to modify SQL statements originally developed by a programmer, which leads to stealing or modifying data to which the attacker has not privileges. Intrusion detection problem is transformed into classification problem, which the objective is to classify SQL queries between either normal or malicious queries. GEP is used to find a function used for classification of SQL queries. Experimental results are presented on the basis of SQL queries of different length. The findings show that the efficiency of detecting SQL statements representing attacks depends on the length of SQL statements.

EvoCOMNET Posters held at General EvoStar poster session on Wednesday 1750-1930

Efficient Signal Processing and Anomaly Detection in Wireless Sensor Networks

Markus Waelchli, Torsten Braun

In this paper the node-level decision unit of a self-learning anomaly detection mechanism for office monitoring with wireless sensor nodes is presented. The node-level decision unit is based on Adaptive Resonance Theory (ART), which is a simple kind of neural networks. The Fuzzy ART neural network used in this work is an ART neural network that accepts analog inputs. A Fuzzy ART neural network represents an adaptive memory that can store a predefined number of prototypes. Any observed input is compared and classified in respect to a maximum number of M online learned prototypes. Considering M prototypes and an input vector size of N, the algorithmic complexity, both in time and memory, is in the order of O(MN). The presented Fuzzy ART neural network is used to process, classify and compress time series of event observations on sensor node level. The mechanism is lightweight and efficient. Based on simple computations, each node is able to report locally suspicious behavior. A system-wide decision is subsequently performed at a base station.

Soft Computing Techniques for Internet Backbone Traffic Anomaly Detection

Antonia Azzini, Matteo De Felice, Sandro Meloni, Andrea G.B. Tettamanzi

The detection of anomalies and faults is a fundamental task for different fields, especially in real cases like LAN networks and the Internet.
We present an experimental study of anomaly detection on a simulated Internet backbone network based on neural networks, particle swarms, and artificial immune systems.

POSTERS CONTINUED

Evolving High-speed, Easy-to-understand Network Intrusion DetectionRules with Genetic Programming

Agustin Orfila, Juan M. Estevez-Tapiador, Arturo Ribagorda

An ever-present problem in intrusion detection technology is how to construct the patterns of (good, bad or anomalous) behaviour upon which an engine have to make decisions regarding the nature of the activity observed in a system. This has traditionally been one of the central areas of research in the field, and most of the solutions proposed so far have relied in one way or another upon some form of data mining--with the exception, of course, of human-constructed patterns. In this paper, we explore the use of Genetic Programming (GP) for such a purpose. Our approach is not new in some aspects, as GP has already been partially explored in the past. Here we show that GP can offer at least two advantages over other classical mechanisms: it can produce very lightweight detection rules (something of extreme importance for high-speed networks or resource-constrained applications) and the simplicity of the patterns generated allows to easily understand the semantics of the underlying attack.

Testing Detector Parameterization using Evolutionary Exploit Generation

Hilmi G. Kayacik, A. Nur Zincir-Heywood, Malcolm I. Heywood, Stefan Burschka

The testing of anomaly detectors is considered from the perspective of a Multi-objective Evolutionary Exploit Generator (EEG). Such a framework provides users of anomaly detection systems two capabilities. Firstly, no knowledge of protected data structures need be assumed. Secondly, the evolved exploits are then able to demonstrate weaknesses in the ensuing detector parameterization. In this work we focus on the parameterization of the second generation anomaly detector 'pH' and demonstrate how use of an EEG may identify weak parameterization of the detector.

Peer-to-peer Optimization in Large Unreliable Networks with Branch-and-Bound and Particle Swarms

Balazs Banhelyi, Marco Biazzini, Alberto Montresor, Mark Jelasity

Decentralized peer-to-peer (P2P) networks (lacking a GRID-style resource management and scheduling infrastructure) are an increasingly important computing platform. So far, little is known about the scaling and reliability of optimization algorithms in P2P environments. In this paper we present empirical results comparing two P2P algorithms for real-valued search spaces in large-scale and unreliable networks. Some interesting, and perhaps counter-intuitive findings are presented: for example, failures in the network can in fact significantly improve performance under some conditions. The two algorithms that are compared are a known distributed particle swarm optimization (PSO) algorithm and a novel P2P branch-and-bound (B&B) algorithm based on interval arithmetic. Although our B&B algorithm is not a black-box heuristic, the PSO algorithm is competitive in certain cases, in particular, in larger networks. Comparing two rather different paradigms for solving the same problem gives a better characterization of the limits and possibilities of optimization in P2P networks.

Ant Routing With Distributed Geographical Localization of Knowledge in Ad-Hoc Networks

Michal Kudelski, Andrzej Pacut

We introduce an alternative way of knowledge management for ant routing in ad-hoc networks. In our approach, the knowledge about paths gathered by ants is connected with geographical locations and exchanged between nodes as they move across the network. The proposed scheme refers to the usage of a pheromone by real ants: the pheromone is left on the ground and used by ants in its surroundings. Our experiments show that the proposed solution may improve the overall performance of the underlying ant routing mechanism.

EvoEnvironment 2009 Thursday 16 April

1615-1745 Session 1 Chair: Marc Ebner

Combining Back-Propagation and Genetic Algorithms to Train Neural Networks for Ambient Temperature Modelling in Italy

Francesco Ceravolo, Matteo De Felice, and Stefano Pizzuti

This paper presents a hybrid approach based on soft computing techniques in order to estimate ambient temperature for those places where such datum is not available. Indeed, we combine the Back-Propagation (BP) algorithm and the Simple Genetic Algorithm (GA) in order to effectively train neural networks in such a way that the BP algorithm initialises a few individuals of the GA's population. Experiments have been performed over all the available Italian places and results have shown a remarkable improvement in accuracy compared to the single and traditional methods.

Estimating the Concentration of Nitrates in Water Samples using PSO and VNS Approaches

Pablo Lopez-Espi, Sancho Salcedo-Sanz, Angel Perez-Bellido, Emilio Ortiz-Garcia, Oscar Alonso-Garrido and Antonio Portilla-Figueras

In this paper we present a study of the application of a Particle Swarm Optimization (PSO) and a Variable Neighborhood Search (VNS) algorithms to the estimation of the concentration of nitrates in water. Our study starts from the definition a model for the Ultra-violet spectrophotometry transmittance curves of water samples with nitrate content. This model consists in a mixture of polynomial, Fermi and Gaussian functions. Then, optimization algorithms must be used to obtain the optimal parameters of the model which minimize the distance between the modeled transmittance curves and a measured curve (curve fitting process [1]). This process allows us to separate the modeled transmittance curve in several components, one of them associated to the nitrate concentration, which can be used to estimate such concentration. We test our proposal in several laboratory samples consisting in water with different nitrate content, and then in three real samples measured in different locations around Madrid, Spain. In these last set of samples, different contaminant can be found, and the problem is therefore harder. The PSO and VNS algorithms tested show good performance in determining the nitrate concentration of water samples.

Optimal Irrigation Scheduling with Evolutionary Algorithms

Michael de Paly, Andreas Zell

Efficient irrigation is becoming a necessity in order to cope with the aggravating water shortage while simultaneously securing the increasing world population's food supply. In this paper, we compare five Evolutionary Algorithms (real valued Genetic Algorithm, Particle Swarm Optimization, Differential Evolution, and two Evolution Strategy-based Algorithms) on the problem of optimal deficit irrigation. We also introduce three different constraint handling strategies that deal with the constraints which arise from the limited amount of irrigation water. We show that Differential Evolution and Particle Swarm Optimization are able to optimize irrigation schedules achieving results which are extremely close to the theoretical optimum.

Adaptive Land-use Management in Dynamic Ecological system

Nanlin Jin, Daniel Chapman, Klaus Hubacek

UK uplands are significantly important in the economy and the environment. There is also a debate on how the banning of managed burning will affect the landscape of uplands. One difficulty in answering such a question comes from the fact that land-use management continuously adapts to dynamic biological environments, which in turn have many impacts on land-use decisions. This work demonstrates how evolutionary algorithms generate land-use strategies in dynamic biological environments over time. It also illustrates the influences on sheep grazing from banning managed burning in a study site.

0930-1100 ## Session 1

Predicting Turning Points in Financial Markets with Fuzzy-Evolutionary and Neuro-Evolutionary Modeling

Antonia Azzini, Andrea G.B. Tettamanzi, Célia Da Costa Pereira

Two independent evolutionary modeling methods, based on fuzzy logic and neural networks respectively, are applied to predicting trend reversals in financial time series, and their performances are compared. Both methods are found to give essentially the same results, indicating that trend reversals are partially predictable.

Knowledge Patterns in Evolutionary Decision Support Systems for Financial Time Series Analysis

Piotr Lipinski

This paper discusses knowledge patterns in evolutionary learning of decision support systems for time series analysis, especially concerning time series of economical or financial data. It focuses on decision support systems, which use evolutionary algorithms to construct efficient expertises built on the basis of a set of specific expert rules analysing time series, such as artificial stock market financial experts composed of popular technical indicators analysing recent price quotations. Discovering common knowledge patterns in such artificial experts not only leads to an additional improvement of system efficiency, in particular - the efficiency of the evolutionary algorithms applied, but also reveals additional knowledge on phenomena under study. This paper shows a numer of experiments carried out on real data, discusses some examples of the knowledge patterns discovered in terms of their financial relevance as well as compares all the results with some popular benchmarks.

Comparison of Multi-Agent Co-Operative Co-Evolutionary and Evolutionary Algorithms for Multi-Objective Portfolio Optimization

Rafal Drezewski, Krystian Obrocki, Leszek Siwik

Co-evolutionary techniques makes it possible to apply evolutionary algorithms in the cases when it is not possible to formulate explicit fitness function. In the case of social and economic simulations such techniques provide us tools for modeling interactions between social or economic agents---especially when agent-based models of
co-evolution are used. In this paper agent-based versions of multi-objective co-operative co-evolutionary algorithms are applied to portfolio optimization problem. The agent-based algorithms are compared with classical versions of SPEA2 and NSGA2 multi-objective evolutionary algorithms.

1100-1130 **Coffee break**

EvoFIN 2009 Thursday 16 April

1130-1300 **Session 2**

Evolutionary Money Management ***Best Paper Nomination

Philip Saks, Dietmar Maringer

This paper evolves trading strategies using genetic programming on high-frequency tick data of the USD/EUR exchange rate covering the calendar year 2006. This paper proposes a novel quad tree structure for trading system design.
The architecture consists of four trees each solving a separate task, but mutually dependent for overall performance. Specifically, the functions of the trees are related to initiating (``entry'') and terminating (``exit'') long and short positions. Thus, evaluation is contingent on the current market position. Using this architecture the paper investigates the effects of money management. Money management refers to certain measures that traders use to control risk and take profits, but it is found that it has a detrimental effects on performance.

Prediction of Interday Stock Prices using Developmental and Linear Genetic Programming ***Best Paper Nomination

Garnett Wilson, Wolfgang Banzhaf

A developmental co-evolutionary genetic programming approach (PAM DGP) is compared to a standard linear genetic programming (LGP) implementation for trading of stocks across market sectors. Both implementations were found to be impressively robust to market fluctuations while reacting efficiently to opportunities for profit, where PAM DGP proved slightly more reactive to market changes than LGP. PAM DGP outperformed, or was competitive with, LGP for all stocks tested. Both implementations had very impressive accuracy in choosing both profitable buy trades and sells that prevented losses, where this occurred in the context of moderately active trading for all stocks. The algorithms also appropriately maintained maximal investment in order to profit from sustained market upswings.

An Introduction to Natural Computing in Finance ***Best Paper Nomination

Jing Dang, Anthony Brabazon, David Edelman, Michael O'Neil

The field of Natural Computing (NC) has advanced rapidly over the past decade. One significant offshoot of this progress has been the application of NC methods in finance. This paper provides an introduction to a wide range of financial problems to which NC methods have been usefully applied. The paper also identifies open issues and suggests multiple future directions for the application of NC methods in finance.

1300-1430 **Lunch**

1430-1600 **Session 3**

Evolutionary approaches for estimating a Coupled Markov Chain model for Credit Portfolio Risk Management

Ronald Hochreiter, David Wozabal

The analysis and valuation of structured credit products gained significant importance during the sub-prime mortgage crisis in 2007. Financial companies still hold many products for which the risk exposure is unknown. The Coupled Markov Chain approach can be used to model rating transitions and thereby default probabilities of companies. The likelihood of the model turns out to be a non-convex function of the parameters to be estimated. Therefore heuristics are applied to find the ML estimators. In this paper, we outline the model and its likelihood function, and present a Particle Swarm Optimization algorithm, as well as an Evolutionary Optimization algorithm to maximize this likelihood function. Numerical results conclude the paper.

Dynamic High Frequency Trading: A Neuro-Evolutionary Approach

Robert Bradley, Anthony Brabazon, Michael O' Neill

Neuro-evolution of augmenting topologies (NEAT) is a recently developed neuro-evolutionary algorithm. This study uses NEAT to evolve dynamic trading agents for the German Bond Futures Market. High frequency data for three German Bond Futures is used to train and test the agents. Four fitness functions are tested and their out of sample performance is presented. The results suggest the methodology can outperform a random agent. However, while some structure was found in the data, the agents fail to yield positive returns when realistic transaction costs are included. A number of avenues of future work are indicated.

1600-1615 **Coffee break**

EvoGAMES 2009 Wednesday 15 April

14:30- 16:00 **Session 1 Chair: Mike Preuss**

Fitness Diversity Parallel Evolution Algorithm in the Turtle Race Game

Matthieu Weber, Ville Tirronen, Ferrante Neri

This paper proposes an artificial player for the Turtle Race game, with the goal of creating an opponent that will provide some amount of challenge to a human player. Turtle Race is a game of imperfect information, where the players know which one of the game pieces is theirs, but do not know which ones belong to the other players and which ones are neutral. Moreover, movement of the pieces is determined by cards randomly drawn from a deck. The artificial player is based on a non-linear neural network whose training is performed by means of a novel parallel evolutionary algorithm with fitness diversity adaptation. The algorithm handles, in parallel, several populations which cooperate with each other by exchanging individuals when a population registers a diversity loss. Four popular evolutionary algorithms have been tested for the proposed parallel framework. Numerical results show that an evolution strategy can be very efficient for the problem under examination and that the proposed adaptation tends to improve upon the algorithmic performance without any addition in computational overhead. The resulting artificial player displayed a high performance against other artificial players and a challenging behavior for expert human players.

Simulation Minus One Makes a Game

Noriyuki Amari, Kazuto Tominaga

This paper presents a way to develop a game using an artificial chemistry. An artificial chemistry is an abstract model of chemical system. It is used in the research field of artificial life. We develop a roguelike game using an artificial chemistry with a specific approach, which we propose in this paper: first, we build a system to simulate the world of a roguelike game; then we remove a part of the system to make it a game. A small set of rules in the artificial chemistry is able to define the simulation, and removing a rule makes it a game. This shows the effectiveness of the present approach in developing a certain type of game using the artificial chemistry.

Swarming for Games: Immersion in Complex Systems

Sebastian von Mammen, Christian Jacob

The swarm metaphor stands for dynamic, complex interaction networks with the possibility of emergent phenomena. In this work, we present two games that challenge the video player with the task to indirectly guide a complex swarm system. First, the player takes control of one swarm individual to herd the remainder of the flock. Second, the player changes the interaction parameters that determine the emergent flight formations, and thereby the flock's success in the game. Additionally, a user-friendly interface for evolutionary computation is embedded to support the player's search for well-performing swarm configurations.

16:20- 17:50 Session 2 Chair: Anna Esparcia

Evolutionary equilibria detection in non-cooperative games

Dan Dumitrescu, Rodica Ioana Lung, Tudor Dan Mihoc

An evolutionary approach for detecting equilibria in non-cooperative game is proposed. Appropriate generative relations (between strategies) are introduced in order to characterize game equilibria. The concept of game is generalized by allowing players to have di®erent types of rationality. Experimental results indicate the potential of the proposed concepts and technique.

Grid coevolution for adaptive simulations; application to the building of opening books in the game of Go

Guillaume Chaslot, Jean-Baptiste Hoock, Arpad Rimmel, Olivier Teytaud, Julien Perez, Pierre Audouard

This paper presents a successful application of parallel (grid) coevolution applied to the building of an opening book (OB) in 9x9 Go. Known sayings around the game of Go are refound by the algorithm, and the resulting program was also able to credibly comment openings in professional games of 9x9 Go. Interestingly, beyond the application to the game of Go, our algorithm can be seen as a "meta"-level for the UCT-algorithm: "UCT applied to UCT" (instead of "UCT applied to a random player" as usual), in order to build an OB. It is generic and could be applied as well for analyzing a given situation of a Markov Decision Process.

Evolving Teams of Cooperating Agents for Real-Time Strategy Game

Pawel Lichocki, Krzysztof Krawiec, Wojciech Jaskowski

We apply gene expression programing to evolve a player for a real-time strategy (RTS) video game. The paper describes the game, evolutionary encoding of strategies and the technical implementation of experimental framework. In the experimental part, we compare two setups that differ with respect to the used approach of task decomposition. One of the setups turns out to be able to evolve an effective strategy, while the other leads to more sophisticated yet inferior solutions. We discuss both the quantitative results and the behavioral patterns observed in the evolved strategies.

EvoGAMES 2009 Wednesday 15 April

EvoGAMES Posters held at General EvoStar poster session on Wednesday 1750-1930

Decay of Invincible Cells of Cooperators in the Evolutionary Prisoner's Dilemma Game
Ching King Chan, Kwok Yip Szeto

Two types of invincible clusters of cooperators are defined in the one-dimensional evolutionary Prisoner's Dilemma game. These invincible clusters can either be peaceful or aggressive. The survival of these invincible clusters is discussed in the context of the repeated Prisoner's Dilemma game with imitation and asynchronous updating procedure. The decay rates for these two types of clusters are analyzed numerically, for all enumeration of the configuration for small chain size.We find characteristic difference in the decay patterns of these two types of invincible clusters. The peaceful invincible clusters experience monotonic exponential decay, while the aggressive ones shows an interesting minimum in the density of cooperators before going through a slow exponential decay at long time. A heuristic argument for the existence of the minima is provided.

Coevolution of Competing Agent Species in a Game-like Environment
Telmo Menezes, Ernesto Costa

Two species of agents coevolve in a 2D, physically simulated world. A simple fitness function rewards agents for shooting at agents of the other species. An evolutionary framework consisting of the gridbrain agent controller model and the SEEA steady-state evolutionary algorithm is used. We were able to observe a phenomenon of species specialization without the need for geographical separation. Species with equal initial conditions were shown to diverge to different specialization niches by way of the systems dynamics. This kind of research may lead to more interesting gaming environments, where the world keeps changing and evolving even in the absence of human interaction.

Evolving Simple Art-based Games
Simon Colton, Cameron Browne

Evolutionary art has a long and distinguished history, and genetic programming is one of only a handful of AI techniques which is used in graphic design and the visual arts. A recent trend in so-called 'new media' art is to design online pieces which are dynamic and have an element of interaction and sometimes simple game-playing aspects. This defines the challenge addressed here: to automatically evolve dynamic, interactive art pieces with game elements. We do this by extending the Avera user-driven evolutionary art system to produce programs which generate spirograph-style images by repeatedly placing, scaling, rotating and colouring geometric objects such as squares and circles. Such images are produced in an inherently causal way which provides the dynamic element to the pieces.We further extend the system to produce programs which react to mouse clicks, and to evolve sequential patterns of clicks for the user to uncover. We wrap the programs in a simple front end which provides the user with feedback on how close they are to uncovering the pattern, adding a lightweight game-playing element to the pieces. The evolved interactive artworks are a preliminary step in the creation of more sophisticated multimedia pieces.

Evolving Strategies for Non-player Characters in Unsteady Environments
Karsten Weicker, Nicole Weicker

Modern computer games place different and more diverse demands on the behavior of non-player characters in comparison to computers playing classical board games like chess. Especially the necessity for a long-term strategy con icts often with game situations that are unsteady, i.e. many non-deterministic factors might change the possible actions. As a consequence, a computer player is needed who might take into account the danger or the chance of his actions. This work examines whether it is possible to train such a player by evolutionary algorithms. For the sake of controllable game situations, the board game Kalah is turned into an unsteady version and used to examine the problem.

1615-1745 **Session 1 Chair: Giovanni Squillero**

Design Optimization of Radio Frequency Discrete Tuning Varactors

Luís Mendes, Eduardo Solteiro Pires, Paulo Oliveira, José Tenreiro Machado, Nuno Ferreira, João Vaz, Maria Rosário

This work presents a procedure to automate the design of Si-integrated radio frequency (RF) discrete tuning varactors (RFDTVs). The synthesis method, which is based on evolutionary algorithms, searches for optimum performance RF switched capacitor array circuits that fulfill the design restrictions. The design algorithm uses the e-dominance concept and the maximin sorting scheme to provide a set of different solutions (circuits) well distributed along an optimal front in the parameter space (circuit size and component values). Since all the solutions present the same performance, the designer can select the circuit that is best suited to be implemented in a particular integration technology. To assess the performance of the synthesis procedure, several RFDTV circuits, provided by the algorithm,
were designed and simulated using a 0.18um CMOS technology and the Cadence Virtuoso Design Platform. The comparisons between the algorithm and circuit simulation results show that they are very close, pointing out that the proposed design procedure is a powerful design tool.

An Evolutionary Path Planner for Multiple Robot Arms

Hector A. Montes, J. Raymundo Marcial

We present preliminary results of a path planner for two robotic arms sharing the same workspace. Unlike many other approaches, our planner finds collision-free paths using the robot's cartesian space as a trade-off between completeness and no workspace preprocessing. Given the high dimensionality of the search space, we use a two phase Genetic Algorithm to find a suitable path in workspaces cluttered with obstacles. Because the length of the path is unknown in advance, the planner manipulates a flexible and well crafted representation which allows the path to grow or shrink during the search process. The performance of our planner was tested on several scenarios where the only moving objects were the two robotic arms. The test scenarios force the manipulators to move through narrow spaces for which suitable and safe paths were found by the planner.

EvoHOT 2009 Thursday 16 April

Evolutionary Optimization of Number of Gates in PLA Circuits Implemented in VLSI Circuits

Adam Slowik, Jacek Zurada

In the paper a possibility of evolutionary number of gate optimization in PLA circuits implemented in VLSI technology is presented. Multi-layer chromosomes and specialized genetic operators cooperating to them are introduced to proposed evolutionary algorithm. Due to multi-layer chromosome structures whole gates are transferred in the logic array without disturb in their structures during crossover operation. Results obtained in optimization of gate number in selection boxes of DES cryptographic algorithm are compared to results obtained using SIS program with different optimization scripts such as: rugged, algebraic, and boolean. Proposed method allows to reduce the gates number in optimized circuit. Results obtained using described evolutionary method are better than using other methods.

Particle Swarm Optimisation as a hardware-oriented meta-heuristic for image analysis

Shahid Mehmood, Stefano Cagnoni, Monica Mordonini, Muddassar Farooq

In this paper we propose a variant of particle swarm optimisation (PSO), oriented at image analysis applications, that is suitable for implementation on hardware chips. The new variant, called HPSO (Hardware PSO), can be mapped easily to field-programmable gate arrays (FPGAs). The modularity of our new architecture permits to
take full advantage of the active dynamic partial reconfiguration allowed by modern FPGAs. Experimental results based on simulations of a license plate detection task are presented to evaluate our design for solving real-world problems.

0930-1100 **Session 1 Chair: Stefano Cagnoni**

Genetic Image Network for Image Classification ***Best Paper Nomination

Shinichi Shirakawa, Shiro Nakayama, Tomoharu Nagao

Automatic construction methods for image processing proposed till date approximate adequate image transformation from original images to their target images using a combination of several known image processing filters by evolutionary computation techniques. Genetic Image Network (GIN) is a recent automatic construction method for image processing. The representation of GIN is a network structure. In this paper, we propose a method of automatic construction of image classifiers based on GIN, designated as Genetic Image Network for Image Classification (GIN-IC). The representation of GIN-IC is a feed-forward network structure. GIN-IC transforms original images to easier-to-classify images using image transformation nodes, and selects adequate image features using feature extraction nodes. We apply GIN-IC to test problems involving multi-class categorization of texture images, and show that the use of image transformation nodes is effective for image classification problems.

Evolutionary optimization for Plasmon-assisted lithography

Caroline Prodhon, Demetrio Macias, Farouk Yalaoui, Alexandre Vial, Lionel Amodeo

We show, through an example in surface-plasmons assisted nano-lithography, the great influence of the definition of the objective function on the quality of the solutions obtained after optimization. We define the visibility and the contrast of a surface-plasmons interference pattern as possible objective functions that will serve to characterize the geometry of a nano-structure. We optimize them with an Elitist Evolution Strategy and compare, by means of some numerical experiments, their effects on the geometrical parameters found. The maximization of the contrast seems to provide solutions more stable than those obtained when the visibility is maximized. Also, it seems to avoid the lack-of-uniqueness problems resulting from the optimization of the visibility.

A Novel GP Approach to Synthesize Vegetation Indices for Soil Erosion Assessment for Soil Erosion Assessment ***Best Paper Nomination

Cesar Puente, Gustavo Olague, Stephen Smith, Stephen Bullock, Miguel Gonzalez-Botello, Alejandro Hinojosa-Corona

Today the most popular method for the extraction of vegetation information from remote sensing data is through vegetation indices. In particular, erosion models are based on vegetation indices that are used to estimate the "cover factor" (C) defined by healthy, dry, or dead vegetation in a popular soil erosion model named RUSLE, ("Revised Universal Soil Loss Equation"). Several works correlate vegetation indices with C in order to characterize a broad area. However, the results are in general not suitable because most indices focus only on healthy vegetation. The aim of this study is to devise a new approach that automatically creates vegetation indices that include dry and dead plants besides healthy vegetation. For this task we propose a novel methodology based on Genetic Programming (GP) as summarized below. First, the problem is posed as a search problem where the objective is to find the index that correlates best with on field C factor data. Then, new indices are built using GP working on a set of numerical operators and bands until the best composite index is found. In this way, GP was able to develop several new indices that are better correlated compared to traditional indices such as NDVI and SAVI family. It is concluded with a real world example that it is viable to synthesize indices that are optimally correlated with the C factor using this methodology. This gives us confidence that the method could be applied in soil erosion assessment.

1100-1130 **Coffee break**

EvoIASP 2009 Thursday 16 April

1130-1300 **Session 2 Chair: Evelyne Lutton**

Multiple Network CGP for the Classification of Mammograms ***Best Paper Nomination

Katharina Völk, Julian Miller, Stephen Smith

This paper presents a novel representation of Cartesian genetic programming (CGP) in which multiple networks are used in the classification of high resolution X-rays of the breast, known as mammograms. CGP networks are used in a number of different recombination strategies and results are presented for mammograms taken from the Lawrence Livermore National Laboratory database.

Flies open a door to SLAM ***Best Paper Nomination

Jean Louchet, Emmanuel Sapin

The ”fly algorithm• is a real-time evolutionary strategy designed for stereovision. Previous work has shown how to process stereo image sequences and use an evolving population of ”flies• as a continuously updated representation of the scene for obstacle avoidance in a mobile robot, and the support to collect information about the environment from different sensors. In this paper, we move a step forward and show a way the fly representation may be used by a mobile robot for its own localisation and build a map of its environment (Simultaneous Localization and Mapping').

Evolving Local Descriptor Operators through Genetic Programming

Cynthia B. Perez, Gustavo Olague

This paper presents a new methodology based on Genetic Programming that aims to create novel mathematical expressions that could improve local descriptors algorithms.We introduce the RDGP-ILLUM descriptor operator that was learned with two image pairs considering rotation, scale and illumination changes during the training stage. Such descriptor operator has a similar performance to our previous RDGP descriptor proposed in Perez and Olague, while outperforming the RDGP descriptor in object recognition application.
A set of experimental results have been used to test our evolved descriptor against three state-of-the-art local descriptors. We conclude that genetic programming is able to synthesize image operators that outperform significantly previous human-made designs.

An Improved Multi-objective Technique for Fuzzy Clustering with Application to IRS Image Segmentation

Ujjwal Maulik, Sanghamitra Bandyopadhyay, Indrajit Saha

In this article a multiobjective technique using improved Differential Evolution for fuzzy clustering has been proposed, that optimizes multiple validity measures simultaneously. The resultant set of near-Pareto-optimal solutions contains a number of nondominated solutions, which the user can judge relatively and pick up the most promising one according to the problem requirements. Real-coded encoding of the cluster centers is used for this purpose. Results demonstrating the effectiveness of the proposed technique are provided for numeric remote sensing data described in terms of feature vectors. One Satellite Image has also been classified using the proposed technique to establish its efficiency.

1615-1745

Session 1 Chair: Evelyne Lutton

Interactive Evolutionary Evaluation through Spatial Partitioning of Fitness Zones

Namrata Khemka, Gerald Hushlak, Christian Jacob

This paper discusses how large-scale interactive evolutionary design can be accomplished through innovative evaluation interfaces. An application example from the world of textile designing and Þne arts serves to illustrate an evolutionary evaluation interface using spatial arrangements. The new interface allows the designer to drag and drop images that represent solutions into Þtness zones on the screen. As our team consists of two computer scientists and an artist, we also explore the collaborative relationships among the team members, and between the artist and the evolutionary system.

Humorized Computational Intelligence - Towards User-Adapting Systems with Sense of Humor

Pawel Dybala, Michal Ptaszynski, Rafal Rzepka, Kenji Araki

This paper investigates the role of humor in non-task oriented (topic restriction free) human-computer dialogue, as well as the correlation between humor and emotions elicited by it in users. A joke-telling conversational system, constructed for the needs of this research, was evaluated by the users as better and more human-like than a baseline system without humor. Automatic emotive evaluation with the usage of an emotiveness analysis system showed that the system with humor elicited more emotions than the other one, and most of them (almost 80%) were positive. This shows that the presence of humor makes computers easier to familiarize with and simply makes users feel better. Therefore, humor should be taken into consideration in research on user-friendly applications, as it enhances the interaction between user and system. The results are discussed and our concept of a user-adapted humor-equipped system is presented.

Fractal Evolver : Interactive Evolutionary Design of Fractals with Grid Computing

Ryan Moniz, Christian Jacob

Interactive Evolutionary Computing is a powerful methodology that can be incorporated into the creative design process. However, for such a system to be useful, the evolutionary process should be simple to understand and easy to operate. This is especially true in applications where it is difficult to create a mathematical formula or model of the fitness evaluation, or where the quality of the solution is subjective and dependent on aesthetics, such as in the areas of art and music. Our paper explores this idea further by presenting a system that evolves fractal patterns using an interactive evolutionary design process. The result is a tool, Fractal Evolver, that employs grid computing and swarm intelligence concepts through particle swarm optimization to evolve fractal designs.

EvoInteraction Poster held at General EvoStar poster session on Wednesday 1750-1930

Innovative Chance Discovery – Extracting Customers' Innovative Concept

Hsiao-Fang Yang, Mu-Hua Lin

The brainstorming is a useful method to collect customers' ideas, and the interactive evolutionary computing (IEC) usually evolves into the personal innovative product according to the designer's preference. In this study, we follow the grounded theory to formulate the framework of interactive chance discovery (ICD). After collected the evolution data, we use social network analysis (SNA) indexes to identify strong-tie and weak-ties relationship. According to the phenomenon of the small world, we believed these complicated relationships include some images of present and future. And these images can help us to discover the market of future. In conclusion, the result of analysis indicated the weak-tie relation can increase the extra innovative concept.

EvoMUSART 2009 Wednesday 15 April

0830 **Registration Desk opens**

0930-0945 **Conference opening and announcements**

0945-1100 **Plenary session: Stuart R Hameroff MD**

1100-1130 **Coffee break**

1130-1300 **Session 1 Chair: Penousal Machado**

Evolved Ricochet Compositions

Gary Greenfield

We consider evolutionary art based on the ricochet art-making technique. With this technique, a sequence of line segments defined by particles moving within the interior of a polygon is developed into a geometric composition by virtue of the fact that reflection (the ricochet) is used to ensure that whenever a particle meets an existing line segment it does not cross it. There is also a rule for filling some of the interior polygons that are formed by particle trajectories based on line color attributes. We establish a genetic infrastructure for this technique and then consider objective measures based on ratio statistics for aesthetically evaluating the results. For the special case of four particles in motion within a square we also examine fitness landscape questions.

Habitat: Engineering in a Simulated Audible Ecosystem

Alan Dorin

This paper introduces a novel approach to generating audio or visual heterogeneity by simulating multi-level habitat formation by ecosystem-engineer organisms. Ecosystem engineers generate habitat by modulation of environmental factors, such as erosion or radiation exposure, and provision of substrate. We describe Habitat, a simulation that runs on a two-dimensional grid occupied by an evolving population of stationary agents. The bodies of these agents provide local, differentiated habitat for new agents. Agents evolve using a conventional evolutionary algorithm that acts on their habitat preferences, habitat provision and lifespan, to populate the space and one another. This generates heterogeneous, dynamic structures that have been used in a prototype sonic artwork and simple visualisation.

Life's what you make: Niche Construction and Evolutionary Art

Jon McCormack, Oliver Bown

This paper advances new methods for ecosystemic approaches to evolutionary music and art. We explore the biological concept of the niche and its role in evolutionary dynamics, applying it to creative computational systems. Using the process of niche construction organisms are able to change and adapt their environment, and potentially that of other species. Constructed niches may become heritable environments for offspring, paralleling the way genes are passed from parent to child. In a creative ecosystem, niche construction can be used by agents to increase the diversity and heterogeneity of their output. We illustrate the usefulness of this technique by applying niche construction to line drawing and music composition.

1430-1600 **Session 2 Chair: Jon McCormack**

On the Role of Temporary Storage in Interactive Evolution

Palle Dahlstedt

In typical implementations of interactive evolution of aesthetic material, population size and generation count are limited due to the time-consuming manual evaluation process. We show how a simple device can help to compensate for this, and help to enhance the functionality of interactive evolution. A temporary storage, defined as a number of easily accessed memory locations for evolved objects, adjacent to the evolving population, can be regarded as a non-evolving extension of the population. If sufficiently integrated into the workflow, it provides compensation for limited genetic diversity, an analogy to elitism selection, and means to escape from stagnation of progress through backtracking and reintroduction of previous genomes. If used in a structured way, it can also help the user form a cognitive map of the search space, and use this map to perform a structured, hierarchical exploration. The discussion is based on experiences from a series of implementations of interactive evolution of music and sound, but should be relevant also for other forms of artistic material.

Evolving Approximate Image Filters

Simon Colton, Pedro Torres

Image filtering involves taking a digital image and producing a new image from it. In software packages such as Adobe's Photoshop, image filters are used to produce artistic versions of original images. Such software usually includes hundreds of different image filtering algorithms, each with many fine-tuneable parameters. While this freedom of exploration may be liberating to artists and designers, it can be daunting for less experienced users. Photoshop provides image filter browsing technology, but does not yet enable the construction of a filter which produces a reasonable approximation of a given filtered image from a given original image. We investigate here whether it is possible to automatically evolve an image filter to approximate a target filter, given only an original image and a filtered version of the original. We describe a tree based representation for filters, the fitness functions and search techniques we employed, and we present the results of experimentation with various search setups. We demonstrate the feasibility of evolving image filters and suggest new ways to improve the process.

Juan Romero, Penousal Machado, Antonino Santos

The lack of a social context is a drawback in current Interactive Evolutionary Computation systems. In application areas where cultural characteristics are particularly important, such as visual arts and music, this problem becomes more pressing. To address this issue, we analyze variants of the traditional Interactive Evolutionary Art approach -- such as multi-user, parallel and partially interactive approaches -- and present an extension of the traditional Interactive Evolutionary Computation paradigm. This extension incorporates users and systems in a Hybrid Society model, that allows the interaction between multiple users and systems, establishing n-m relations among them, and promotes cooperation.

EvoMUSART 2009 Wednesday 15 April

1600-1620 **Coffee break**

1620-1750 **Session 3 Chair: Juan Romero**

Global Expectation-Violation as Fitness Function in Evolutionary Composition

Tim Murray Browne, Charles Fox

Previous approaches to Common Practice Period style automated composition - such as Markov models and Context-Free Grammars (CFGs) - do not well characterise global, context-sensitive structure of musical tension and release. Using local musical expectation violation as a measure of tension, we show how global tension structure may be extracted from a source composition and used in a fitness function. We demonstrate the use of such a fitness function in an evolutionary algorithm for a highly constrained task of composition from pre-determined musical fragments. Evaluation shows an automated composition to be effectively indistinguishable from a similarly constrained composition by an experienced composer.

Composing using Heterogeneous Cellular Automata

Somnuk Phon-Amnuaisuk

Music composition is a highly intelligent activity. Composers exploit a large number of possible patterns and creatively compose a new piece of music by weaving various patterns together in a musically intelligent manner. Many researchers have investigated algorithmic compositions and realised the limitations of knowledge elicitation and knowledge exploitation in a given representation/computation paradigm. This paper discusses the applications of heterogeneous cellular automata (hetCA) in generating chorale melodies and Bach chorales harmonisation. We explore the machine learning approach in learning rewrite-rules of cellular automata. Rewrite-rules are learned from music examples using a time-delay neural network. After the hetCA has successfully learned musical patterns from examples,new compositions are generated from the hetCA model.

The Evolution of Evolutionary Software: Intelligent Rhythm Generation in Kinetic Engine

Arne Eigenfeldt

This paper presents an evolutionary music software system that generates complex rhythmic polyphony in performance. A population of rhythms is derived from analysis of source material, using a first order Markov chain derived from subdivision transitions. The population evolves in performance, and each generation is analysed to provide rules for subsequent generations.

Filterscape: Energy Recycling in a Creative Ecosystem

Alice Eldridge, Alan Dorin

This paper extends previous work in evolutionary ecosystemic approaches to generative art. Filterscape, adopts the implicit fitness specification that is fundamental to this approach and explores the use of resource recycling as a means of generating coherent sonic diversity in a generative sound work. Filterscape agents consume and deposit energy that is manifest in the simulation as sound. Resource recycling is shown to support cooperative as well as competitive survival strategies. In the context of our simulation, these strategies are recognised by their characteristic audible signatures. The model provides a novel means to generate sonic diversity through de-centralised agent interactions.

EvoMUSART Posters held at General EvoStar poster session on Wednesday 1750-1930

Generation of Pop-Rock Accompaniments Using Genetic Algorithms and Variable Neighborhood Search
Leonardo Lozano, Nubia Velasco, Andres Medaglia
This work proposes a utility function that measures: 1) the vertical relation between notes in a melody and chords in a sequence, and 2) the horizontal relation among chords. This utility function is embedded in a procedure that combines a Genetic Algorithm (GA) with a Variable Neighborhood Search (VNS) to automatically generate style-based chord sequences. The two-step algorithm is tested in ten popular songs, achieving accompaniments that match closely those of the original versions.

Extending Context Free to Teach Interactive Evolutionary Design Systems / Teaching Evolutionary Design Systems by Extending ``Context Free''
Rob Saunders, Kazjon Grace
This document reports on a case study using a novel approach to teaching generative design systems. The approach extends Context Free, a popular design grammar for producing 2D imagery, to support parametric and evolutionary design. We present some of the challenges that design students have typically faced when learning about generative systems. We describe our solution to providing students with a progressive learning experience from design grammars, through parametric design, to evolutionary design. We conclude with a discussion of the benefits of our approach and some directions for future developments.

A GA-based Control Strategy to Create Music with a Chaotic System
Costantino Rizzuti, Eleonora Bilotta, Pietro Pantano
Chaotic systems can be used to generate sounds and music. Establishing a musical interaction with such systems is often a difficult task. Our research aims at improve the extent of interaction provided by a generative music system by using an evolutionary methods. A musician can hear and imitate what the generative system produces; therefore, we are interested in defining a control strategy to allow the generative music system to imitate the musical gesture provided by the musician.

Artificial Nature : : Immersive World Making
Graham Wakefield, Haru Ji
Artificial Nature is a trans-disciplinary research project drawing upon bio-inspired system theories in the production of engaging immersive worlds as art installations. Embodied world making and immersion are identified as key components in an exploration of creative ecosystems toward art-as-it-could-be. A detailed account of the design of a successfully exhibited creative ecosystem is given in these terms, and open questions are outlined.

Evolving Indirectly Represented Melodies with Corpus-based Fitness Evaluation
Jacek Wolkowicz, Malcolm Heywood, Vlado Keselj
The paper addresses the issue of automatic generation of music excerpts. The character of the problem makes it suitable for various kinds of evolutionary computation algorithms. We introduce a special method of indirect melodic representation that allows simple application of standard search operators like crossover and mutation with no repair mechanisms necessary. A method is proposed for automatic evaluation of melodies based upon a corpus of manually coded examples, such as classical music opi. Various kinds of Genetic Algorithm (GA) were tested against this e.g., generational GAs and steady-state GAs. The results show the ability of the method for further applications in the domain of automatic music composition.

Posters continued

Elevated Pitch: Automated Grammatical Evolution of Short Compositions
John Reddin, James McDermott, Michael O'Neill
A system for automatic composition using grammatical evolution is presented. Music is created under the constraints of a generative grammar, and under the bias of an automatic fitness function and evolutionary selection. This combination of two methods is seen to be powerful and flexible. Human evaluation of automatically-evolved pieces shows that a more sophisticated grammar in combination with a naive fitness function gives better results than the reverse.

An algorithm for an Evolutionary Music Composer
Roberto De Prisco, Rocco Zaccagnino
In this paper we present an automatic Evolutionary Music Composer algorithm and a preliminary prototype software that implements it. The specific music composition problem that we consider is the so called unfigured (or figured) bass problem: a bass line is given (sometimes with information about the chords to use) and the automatic composer has to write other 3 voices to have a complete 4-voice piece of music. By automatic we mean that there must be no human intervention in the composing process. We use a genetic algorithm to tackle the figured bass problem and an ad-hoc algorithm to transform an unfigured bass to a figured bass. In this paper we focus on the genetic algorithm.

0930-1100 **EvoNUM Session 1 Chair: Aniko Ekart**

Memetic Variation Local Search vs Life-time Learning in Electrical Impedance Tomography

Jyri Leskinen, Ferrante Neri, Pekka Neittaanmaki

In this article, various metaheuristics for a numerical optimization problem with application to Electric Impedance Tomography are tested and compared. The experimental setup is composed of a real valued Genetic Algorithm, the Differential Evolution, a self adaptive Differential Evolution recently proposed in literature, and two novel Memetic Algorithms designed for the problem under study. The two proposed algorithms employ different algorithmic philosophies in the field of Memetic Computing. The first algorithm integrates a local search into the operations of the offspring generation, while the second algorithm applies a local search to individuals already generated in the spirit of life-time learning. Numerical results show that the fitness landscape and difficulty of the optimization problem heavily depends on the geometrical configuration, as well the proposed Memetic Algorithms seem to be more promising when the geometrical conditions make the problem harder to solve.

Estimating HMM Parameters using Particle Swarm Optimisation

Somnuk Phon-Amnuaisuk

A Hidden Markov Model (HMM) is a powerful model in describing temporal sequences. The HMM parameters are usually estimated using Baum-Welch algorithm. However, it is well known that the Baum-Welch algorithm tends to arrive at local optimal points. In this report, we investigate the potential of the Particle Swarm Optimisation (PSO) as an alternative method for HMM parameters estimation. The domain in this study is the recognition of handwritten music notations. Three observables: (i) sequence of ink patterns, (ii) stroke information and (iii) spatial information associated with eight musical symbols were recorded. Sixteen HMM models were built from the data. Eight HMM models for eight musical symbols were built from the parameters estimated using the Baum-Welch algorithm and the other eight models were built from the parameters estimated using PSO. The experiment shows that the performances of HMM models, using parameters estimated from PSO and Baum-Welch approach, are comparable. We suggest that PSO or a combination of PSO and Baum-Welch algorithm could be alternative approaches for the HMM parameters estimation.

Modeling Pheromone Dispensers Using Genetic Programming

Eva Alfaro-Cid, Anna I. Esparcia-Alcazar, Pilar Moya, Beatriu Femenia-Ferrer, Ken Sharman, J.J. Merelo

Mating disruption is an agricultural technique that intends to substitute the use of insecticides for pest control. This technique consists of the diffusion of large amounts of sexual pheromone, so that the males are confused and mating is disrupted. Pheromones are released using devices called dispensers. The speed of release is, generally, a function of time and atmospheric conditions such as temperature and humidity. One of the objectives in the design of the dispensers is to minimise the effect of atmospheric conditions in the performance of the dispenser. With this objective, the Centro de Ecologia Quimica Agricola (CEQA) has designed an experimental dispenser that aims to compete with the dispensers already in the market. The hypothesis we want to validate (and which is based on experimental results) is that the performance of the CEQA dispenser is independent of the atmospheric conditions, as opposed to the most widely used commercial dispenser, Isomate CPlus. This was done using a genetic programming (GP) algorithm. GP evolved functions able to describe the performance of both dispensers and that support the initial hypothesis.

EvoNUM 2009 Thursday 16 April

1100-1130 **Coffee break**

1130-1300 **EvoNUM Session 2 Chair: Anna I Esparcia-Alcázar**

NK landscapes difficulty and Negative Slope Coefficient: How Sampling Influences the Results

Leonardo Vanneschi, Sebastien Verel, Marco Tomassini, Philippe Collard

Negative Slope Coefficient is an indicator of problem hardness that has been introduced in 2004 and that has returned promising results on a large set of problems. It is based on the concept of fitness cloud and works by partitioning the cloud into a number of bins representing as many different regions of the fitness landscape. The measure is calculated by joining the bins centroids by segments and summing all their negative slopes. In this paper, for the first time, we point out a potential problem of the Negative Slope Coefficient: we study its value for different instances of the well known NK-landscapes and we show how this indicator is dramatically influenced by the minimum number of points contained in a bin. Successively, we formally justify this behavior of the Negative Slope Coefficient and we discuss pros and cons of this measure.

On the parallel speed-up of Estimation of Multivariate Normal Algorithm and Evolution Strategies ***Best Paper Nomination

Fabien Teytaud, Olivier Teytaud

Motivated by parallel optimization, we experiment EDA-like adaptation-rules in the case of lambda large. The rule we use, essentially based on estimation of multivariate normal algorithm, is (i) compliant with all families of distributions for which a density estimation algorithm exists (ii) simple (iii) parameter-free (iv) better than current rules in this framework of lambda large. The speed-up as a function of lambda is consistent with theoretical bounds.

Adaptability of Algorithms for Real-Valued Optimization ***Best Paper Nomination

Mike Preuss

We investigate the adaptability of optimization algorithms for the real-valued case to concrete problems via tuning. However, the focus is not primarily on performance, but on the tuning potential of each algorithm/problem system, for which we define the empirical tuning potential measure (ETP). It is tested if this measure fulfills some trivial conditions for usability, which it does.We also compare the best obtained configurations of 4 adaptable algorithms (2 evolutionary, 2 classic) with classic algorithms under default settings. The overall outcome is quite mixed: Sometimes adapting algorithms is highly profitable, but some problems are already solved to optimality by classic methods.

1300-1430 **Lunch at the Mensa**

EvoNUM Posters held at General EvoStar poster session on Wednesday 1750-1930

A stigmergy-based algorithm for continuous optimization tested on real-life-like environment
Peter Korosec, Jurij Silc

This paper presents a solution to the global optimization of continuous functions by the Differential Ant-Stigmergy Algorithm (DASA). The DASA is a newly developed algorithm for continuous optimization problems, utilizing the stigmergic behaviour of the artificial ant colonies. It is applied to the high-dimensional real-parameter optimization with low number of function evaluations. The performance of the DASA is evaluated on the set of 25 benchmark functions provided by CEC'2005 Special Session on Real Parameter Optimization. Furthermore, non-parametric statistical comparisons with eleven state-of-the-art algorithms demonstrate the effectiveness and efficiency of the DASA.

Stochastic Local Search Techniques with Unimodal Continuous Distributions: A Survey
Petr Posik

In continuous black-box optimization, various stochastic local search techniques are often employed, with various remedies for fighting the premature convergence. This paper surveys recent developments in the field (the most important from the author's perspective), analyzes the differences and similarities and proposes a taxonomy of these methods. Based on this taxonomy, a variety of novel, previously unexplored, and potentially promising techniques may be envisioned.

Evolutionary Optimization guided by Entropy-based Discretization
Guleng Sheri, David Corne

The Learnable Evolution Model (LEM) involves alternating periods of optimization and learning, performa extremely well on a range of problems, a specialises in achieveing good results in relatively few function evaluations. LEM implementations tend to use sophisticated learning strategies. Here we continue an exploration of alternative and simpler learning strategies, and try Entropy-based Discretization (ED), whereby, for each parameter in the search space, we infer from recent evaluated samples what seems to be a `good' interval. We find that LEM(ED) provides significant advantages in both solution speed and quality over the unadorned evolutionary algorithm, and is usually superior to CMA-ES when the number of evaluations is limited. It is interesting to see such improvement gained from an easily-implemented approach. LEM(ED) can
be tentatively recommended for trial on problems where good results are needed in relatively few fitness evaluations, while it is open to several routes of extension and further sophistication. Finally, results reported here are not based on a modern function optimization suite, but ongoing work confirms that our findings remain valid for non-separable functions.

EvoSTOC 2009 Wednesday 15 April

1130-1300 **Session 1**

The Influence of Population and Memory Sizes on the Evolutionary Algorithm's Performance for Dynamic Environments

Anabela Simões, Ernesto Costa

Usually, evolutionary algorithms keep the size of the population fixed. In the context of dynamic environments, many approaches divide the main population into two, one part that evolves as usual another that plays the role of memory of past good solutions. The size of these two populations is often chosen off-line. Usually memory size is chosen as a small percentage of population size, but this decision can be a strong weakness in algorithms dealing with dynamic environments. In this work we do an experimental study about the importance of this parameter for the algorithm's performance. Results show that tuning the population and memory sizes is not an easy task and the impact of that choice on the algorithm's performance is significant. Using an algorithm that dynamically adjusts the population and memory sizes outperforms the standard approaches.

Differential Evolution with Noise Analyzer

Andrea Caponio, Ferrante Neri

This paper proposes a Differential Evolution based algorithm for numerical optimization in the presence of noise. The proposed algorithm, namely Noise Analysis Differential Evolution (NADE), employs a randomized scale factor in order to overcome the structural difficulties of a Differential Evolution in a noisy environment as well as a noise analysis component which determines the amount of samples required for characterizing the stochastic process and thus efficiently performing pairwise comparisons between parent and offspring solutions. The NADE has been compared, for a benchmark set composed of various fitness landscapes under several levels of noise bandwidth, with a classical evolutionary algorithm for noisy optimization and two recently proposed metaheuristics. Numerical results show that the proposed NADE has a very good performance in detecting high quality solutions despite the presence of noise. The NADE seems, in most cases, very fast and reliable in detecting promising search directions and continuing evolution towards the optimum.

An Immune System Based Genetic Algorithm Using Permutation-Based Dualism for Dynamic Traveling Salesman Problems

Lili Liu, Dingwei Wang, Shengxiang Yang

In recent years, optimization in dynamic environments has attracted a growing interest from the genetic algorithm community due to the importance and practicability in real world applications. This paper proposes a new genetic algorithm, based on the inspiration from biological immune systems, to address dynamic traveling salesman problems. Within the proposed algorithm, a permutation-based dualism is introduced in the course of clone process to promote the population diversity. In addition, a memory-based vaccination scheme is presented to further improve its tracking ability in dynamic environments. The experimental results show that the proposed diversification and memory enhancement methods can greatly improve the adaptability of genetic algorithms for dynamic traveling salesman problems.

1300-1430 **Lunch at the Mensa**

1430-1600 **Session 2**

Dynamic Time-linkage Problems Revisited

Trung Thanh Nguyen, Xin Yao

Dynamic time-linkage problems (DTPs) are common types of dynamic optimization problems where "decisions that are made now ...may influence the maximum score that can be obtained in the future"[3]. This paper contributes to understanding the questions of what are the unknown characteristic of DTPs and how to characterize DTPs. Firstly, based on existing de?nitions we will introduce a more detailed definition to help characterize DTPs. Secondly, although it is believed that DTPs can be solved to optimality with a perfect prediction method to predict function values [3] [4], in this paper we will discuss a new class of DTPs where even with such a perfect prediction method algorithms might still be deceived and hence will not be able to get the optimal results. We will also propose a benchmark problem to study that particular type of time-linkage problems.

The Dynamic Knapsack Problem Revisited: A New Benchmark Problem for Dynamic Combinatorial Optimisation

Philipp Rohlfshagen, Xin Yao

In this paper we propose a new benchmark problem for dynamic combinatorial optimisation. Unlike most previous benchmarks, we focus primarily on the underlying dynamics of the problem and consider the distances between successive global optima only as an emergent property of those dynamics. The benchmark problem is based upon a class of difficult instances of the 0/1-knapsack problem that are generated using a small set of real-valued parameters. These parameters are subsequently varied over time by some set of difference equations: It is possible to model approximately different types of transitions by controlling the shape and degree of interactions between the trajectories of the parameters. We conduct a set of experiments to highlight some of the intrinsic properties of this benchmark problem and find it not only to be challenging but also more representative of real-world scenarios than previous benchmarks in the field. The attributes of this benchmark also highlight some important properties of dynamic optimisation problems in general that may be used to advance our understanding of the relationship between the underlying dynamics of a problem and their manifestation in the search space over time.

EvoSTOC Posters held at General EvoStar poster session on Wednesday 1750-1930

Impact of Frequency and Severity on Non-stationary Optimization Problems

Enrique Alba, Gabriel Luque, Daniel Arias

Frequency and severity are a priori very influential parameters in the performance of Dynamic Optimization Problems because they establish when and how hard is the change of the target optimized function. We study in a systematic way their influence in the performance of Dynamic Optimization Problems and the possible mathematical correlations between them. Specifically, we have used a steady state Genetic Algorithm, which has been applied to three classic Dynamic Optimization Problems considering a wide range of frequency and severity values. The results show that the severity is the more important parameter influencing the accuracy of the algorithm.

A Critical Look at Dynamic Multi-Dimensional Knapsack Problem Generation

Sima Uyar, H. Turgut Uyar

The dynamic, multi-dimensional knapsack problem is an important benchmark for evaluating the performance of evolutionary algorithms in changing environments, especially because it has many real-world applications. In order to analyze the performance of an evolutionary algorithm according to this benchmark, one needs to be able to change the current problem in a controlled manner. Several methods have been proposed to achieve this goal. In this paper, we briefly outline the proposed methods, discuss their shortcomings and propose a new method that can generate changes for a given severity level more reliably. We then present the experimental setup and results for the new method and compare it with existing methods. The current results are promising and promote further study.

1430-1600 **Session 1: Transportation Chair: Andreas Fink**

Evolutionary Freight Transportation Planning ***Best Paper Nomination

Thomas Weise, Alexander Podlich, Kai Reinhard, Christian Gorldt, Kurt Geihs

In this paper, we present the freight transportation planning component of the INWEST project. This system utilizes an evolutionary algorithm with intelligent search operations in order to achieve a high utilization of resources and a minimization of the distance travelled by freight carriers in real-world scenarios. We test our planner rigorously with real-world data and obtain substantial improvements when compared to the original freight plans. Additionally, different settings for the evolutionary algorithm are studied with further experiments and their utility is verified with statistical tests.

An Effective Evolutionary Algorithm for the Cumulative Capacitated Vehicle Routing Problem

Sandra Ulrich Ngueveu, Christian Prins, Roberto Wolfler-Calvo

The Cumulative Capacitated Vehicle Routing Problem (or CCVRP) models transportation problems where the objective is to minimize the sum of arrival times at customers, taking into account capacity limitations. It generalizes the traveling repairman problem (or TRP), by adding capacity constraints and an homogeneous vehicle fleet. This paper presents the first metaheuristic designed for the CCVRP, taking into account specific properties to improve its speed and efficiency. The algorithm obtained also becomes the best metaheuristic for the TRP.

Heuristic Algorithm for Coordination in Public Transport under Disruptions

Ricardo García, Máximo Almodóvar, Francisco Parreño

This paper deals with on-line coordination of public transport systems under disruptions. An on-line optimization model is proposed in order to support decisions about how to balance all the fleet of transit lines in the public transport system and also to minimize waiting time caused by disruption. A fast heuristic algorithm is developed for the on-line problem and a numerical study of the regional train network of Madrid is carried out.

1600-1615 **Coffee break**

1615-1745 **Session 2: Supply Chain Management Chair: Franz Rothlauf**

Optimal Co-Evolutionary Strategies for the Competitive Maritime Network Design Problem

Loukas Dimitriou, Antony Stathopoulos

The current paper is focusing into the less well-defined transportation networks as those that are formed by the integration (combination) of alternative transportation means for servicing freight movements and the special inter-dependencies that are developed by this integration. Here the market of maritime facilities is modelled as an n-person non-cooperative game among port authorities who control the attractiveness of their terminal facilities. By taking the above interdependencies into consideration, optimal decisions of port authorities are obtained by extending the classical single leader-multiple followers Stackelberg game-theoretic formulation of the Network Design Problem (NDP) to its complete form of multiple leaders-multiple followers Competitive NDP (CNDP). The estimation of the equilibrium point of the above formulation is made by incorporating a novel evolutionary game-theoretic genetic operator into a hybrid Genetic Algorithm. The results from the application of the proposed framework into a realistic part of the East Mediterranean freight network show the potential of the method to support decisions of port authorities concerning future infrastructure investments.

A Corridor Method-based Algorithm for the Pre-marshalling Problem

Marco Caserta, Stefan Voß

To ease the situation and to ensure a high performance of ship, train and truck operation at container terminals, containers sometimes are pre-stowed near to the loading place and in such an order that it fits the loading sequence. This is done after the stowage plan is finished and before ship loading starts. Such a problem may be referred to as pre-marshalling. Motivated by most recent publications on this problem we describe a metaheuristic approach which is able to solve this type of problem. The approach utilizes the paradigm of the corridor method.

Comparison of Metaheuristic Approaches for Multi-objective Simulation-based Optimization in Supply Chain Inventory Management

Lionel Amodeo, Christian, Prins, David Ricardo Sanchez

A Supply Chain (SC) is a complex network of facilities with dissimilar and conflicting objectives, immersed in an unpredictable environment. Discrete-event simulation is often used to model and capture the dynamic interactions occurring in the SC and provide SC performance indicators.However, a simulator by itself is not an optimizer. This paper therefore considers the hybridization of Evolutionary Algorithms (EAs), well known for their multi-objective capability, with an SC simulation module in order to determine the inventory policy (order-point or order-level) of a single product SC, taking into account two conflicting objectives: the maximization of customer service level and the total inventory cost.Different evolutionary approaches, such as SPEA-II, SPEA-IIb, NSGA-II and MO-PSO, are tested in order to decide which algorithm is the most suited for simulation-based optimization. The research concludes that SPEA-II favors a rapid convergence and that variation and crossover schemes play and important role in reaching the true Pareto front in a reasonable amount of time.