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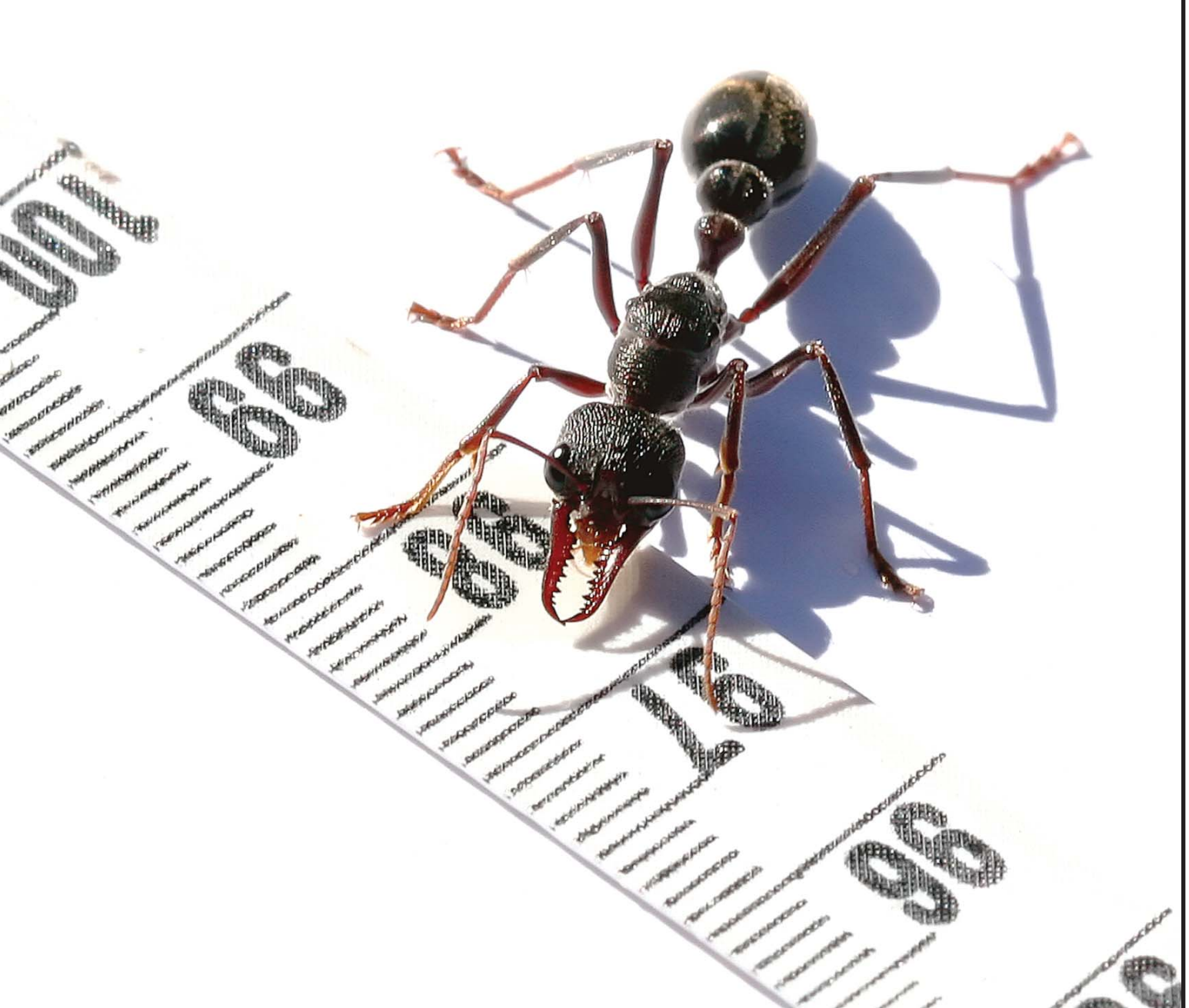

in this issue

Editorial

Welcome to the summer issue of SIGEVOlution! You are probably wondering "What summer issue? It is winter already!" But yes, this is the summer issue. I do apologize for this huge delay caused by a series of unfortunate events. Three out of the four papers that were scheduled to appear in the summer and autumn issues could not be sent and this has dramatically slowed us down. The important fact is however that we are now celebrating the end of 2007 with a new issue!

As the cover suggests this issue deals with ants. In the first article, Dario Coltorti and Andrea E. Rizzoli report on three applications of ant colony optimization for vehicle routing problems that have been developed at AntOptima—a company that recently received the Swiss Technology Award 2007. Martin Butz presents his XCSF classifier system Java implementation. Fernando Lobo tells us about a little (lost) gem he found, the paper "The Equilibrium Genetic Algorithm and the Role of Crossover" by Ari Juels, Shumeet Baluja, and Alistair Sinclair. The columns provide information about several announcements, the forthcoming issues of EC journals, new books, and the calendar of EC events.

The cover photo is by "young_einstein" who defines himself as a self taught amateur photographer, born and raised in Melbourne, Australia. I found it on www.flickr.com; he has many other beautiful shots here.

I thank the people who made this issue possible, Dario Coltorti, Andrea E. Rizzoli, Martin V. Butz, Fernando G. Lobo, Risto Miikkulainen, Kenneth Stanley, Igor Karpov, Larry Bull, Daniel R. Tauritz, Stewart Wilson, Dave Davis and Martin Pelikan.

In conclusion, I wish to stress that the newsletter, as an expression of the EC community, needs you—your ideas, your suggestions, and also your criticisms.

Pier Luca
December 12th, 2007

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Contributors to this Issue

Dario Coltorti
Andrea E. Rizzoli
Martin V. Butz
Fernando G. Lobo

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Ant Colony Optimization for Real-world Vehicle Routing Problems

Dario Coltorti, dario.coltorti@antoptima.ch, AntOptima SA, Lugano, Switzerland
Andrea E. Rizzoli, andrea.rizzoli@antoptima.ch, AntOptima SA, Lugano, Switzerland

Metaheuristics like ant colony optimization (ACO) can be used to solve combinatorial optimization problems. In this paper we refer to its successful application to the vehicle routing problem (VRP). At the beginning, we introduce the VRP and some of its variants. The variants of VRP were designed to reproduce the kind of situations faced in the real-world. Further, we introduce the fundamentals of ant colony optimization, and we present in few words its application to the solution of the VRP. At the end, we discuss the applications of ACO to a number of real-world problems: a VRP with time windows for a major supermarket chain in Switzerland; a VRP with pickup and delivery for a leading distribution company in Italy and an on-line VRP in the city of Lugano, Switzerland, where clients' orders arrive during the delivery process.

Introduction

Most logistics problems are particularly challenging as their search space grows exponentially with the problem dimensions and no efficient algorithms to explore such space are known. For these problems, which are technically known as NP-hard, the time required to find an optimal solution might be simply too high for practical purposes.

Heuristics methods have been devised to explore parts of the search space, concentrating in those parts that appear to be most promising, thus reducing the time required to obtain a sub-optimal, but still good enough, solution. A heuristic makes use of peculiar characteristics of a problem and exploits them to find a solution. Therefore a heuristic has to be especially devised for each new problem.

A metaheuristic is a set of concepts that can be used to define heuristic methods that can be applied to a wide set of different problems [16]. Well known examples of metaheuristics include simulated annealing (SA), tabu search (TS), iterated local search (ILS), evolutionary algorithms (EC), and ant colony optimization (ACO), the subject of this paper.

Ant Colony Optimization (ACO) is based on the observation that ants can find the optimal path between a food source and their nest exploiting a mix of probabilistic behavior and pheromone depositing. In fact, in ACO a set of artificial ants somehow simulate the behavior of real ants; the artificial ants move on the graph representation of a combinatorial optimization problem and build solutions probabilistically. The probabilities are biased by artificial pheromones that ants deposit while building solution (for a recent overview of ACO see [3]; for a detailed description [8]). In this paper we discuss how ACO can be successfully applied to the solution of real-world vehicle routing problems.

The Vehicle Routing Problem

The vehicle routing problem can be designed as a combinatorial optimization problem: Finding optimal routes for a fleet of vehicles performing assigned tasks on a number of geographically sectored clients. An answer to this problem is the best route serving all clients using a fleet of vehicles, respecting all operational constraints, such as vehicle capacity and the driver's maximum working time, and minimizing the total transportation cost.

There are 3 main factors that define and constrain each model of the VRP: the road network, specifying the relatedness among clients and depots, the vehicles, transporting goods between clients and depots on the road network; the clients, which place orders and receive goods.

Joining the various factors of the problem, we can define a whole set of different VRPs (for a detailed overview of the various VRPs see [20]). All these variants have been created in order to bring the VRP closer to the kind of situations faced in the real-world. Table 1 shows some important VRP starting from basic version, continuing by static case (VRP with time windows, VRP with time windows and pick-up and delivery constraints) and finishing by dynamic case (time dependent VRP like on-line VRP).

Optimization Framework Inspired By Ants

Ant colony optimization [5] is a metaheuristic inspired by the observation, made by ethologists, that ants are able to find the shortest path to a food source by laying and following chemical trails. The chemical substance which ants use to communicate information regarding the shortest path to food is called pheromone. Communicate means that a moving ant lays some pheromone on the ground, thus marking a path with a trail of this substance. In the majority of cases an isolated ant moves randomly and when it discovers a previously laid pheromone trail it can decide, with high probability, to follow it, thus reinforcing the trail with its own pheromone. The group behavior that results is a form of self-organisational process where the more ants follow a trail, the more attractive for other ants it becomes. The process running by basic rules is characterised by a positive feedback loop, where the probability with which an ant chooses a path increases with the number of ants that previously chose the same path. Other positive characteristics of the above process are the flexibility (adaptability) and the robustness (system doesn't depend on one ant). This group behavior of ants with its positive attributes inspired the ACO metaheuristic. The main factors are artificial ants (called from now on ants), simple computational agents that individually and iteratively construct solutions on a graph, which has been modeled depending on the specific problem. A problem solution is an ordered sequence of nodes connected by edges visited by exploring ants. Ants compute a solution in parallel, deploying the search process over several constructive computational threads. A dynamic memory structure, inspired by the pheromone laying process, guides the construction process of each thread.

The memory structure incorporates information on the effectiveness of previously obtained results. Intermediate partial problem solutions are seen as states; at each iteration k of the algorithm each ant moves from state x k (i) to x k+1 (j), enlarging the partial solution from node i adding node j.

Based on these elements the first ACO algorithm to be proposed was Ant System (AS) [7]. It is organized in two main stages: construction of a solution, and update of the pheromone trail. Since its publication different variants have been proposed to improve the solutions of combinatorial optimization problems: elitist ant system [4], rank-based ant system [1], and Max – Min ant system [19] are variants, where the algorithm differs from the original mainly in the pheromone update rule. On the other hand, extensions of AS display more substantial changes in the algorithm structure. Ant Colony System (ACS, [6]) is one of them. ACS differs from AS for a revised rule used in the tour construction algorithm, and for the use of both local and global updates of the pheromone trails.

ACS has been shown to be very efficient in solving problems of the vehicle routing class, ranging from the static case (VRP with time windows, and VRP with time windows and pick-up and delivery constraints) to the dynamic case (on-line VRP). In the next section we describe how ACO has been applied in a number of cases to solve real world logistic problems.

Major supermarket chains: Distribution of goods from inventory stores to shops

In this business case one of the major supermarket chains in Switzerland has the following challenge: Palletized goods must be distributed to more than 600 stores, all over Switzerland. To replenish their local stocks each store orders daily quantities of goods, which have to be delivered within time windows. So each store can plan and allocate efficiently according to the daily availability of its personnel and the time requested for inventory management tasks. Further there are three types of vehicles: trucks (capacity: 17 pallets), trucks with trailers (35 pallets), and tractor units with semi-trailers (33 pallets). One practical restriction is the access of vehicles to the store, which depends on the store location. In some cases the truck with trailer can leave the trailer at a previous store and then continue to other less accessible locations. Moreover the number of vehicles is assumed to be infinite, since transport services can be purchased on the market according to the needs.

Problem Type	Constraints	Objective	NP-hard Problem (yes/no)
Capacitated vehicle routing problem (CVRP, basic version of the VRP)	- Having vehicles with limited capacity - Client demands are deterministic and known in advance - Deliveries cannot be split - Vehicle fleet is homogeneous	Minimise the total travel cost	Yes [13]
Vehicle routing Problem with time window (VRPTW) [15, 14, 12]	Each Client is associated with a time window and a service time	Minimise the total travel cost	Yes [18]
VRP with pick-up and delivery (VRPPD) [2]	The transport items are not originally concentrated in the depots, but they are distributed over the nodes of the road network. A transportation request consists in transferring the demand from the pick-up point to the delivery point. These problems always include time windows for pick-up and/or delivery.	Minimise the total travel cost	Yes
Probabilistic, dynamic and stochastic vehicle routing (assumed generic term: Dynamic VRP) like online VRP [10]	The assumption of time invariancy must be relaxed and data become time-dependent. Moreover, using data on current traffic conditions to estimate travel times requires the relaxation of the assumption of determinism, introducing uncertainty and adding another level of complexity to the problem.	Minimise the total travel cost.	Yes

Tab. 1: Important vehicle routing problems.

	Human Planner	AR-RegTW	AR-Free
Total number of tours	2056	1807	1614
Total km	147271	143983	126258
Average truck loading	76.91%	87.35%	97.81%

Tab. 2: Comparison of the man-made vs. the computer-generated tours in the VRPTW application.

The road network graph could be computed due to digital road maps. On the other hand the distance matrix between pairs of stores has been rescaled using a company speed model, based on many years of experiences and collecting data. For example, if the distance is less than 5 km, the average speed is 20 km/h; if the distance is more than 90 km, the speed is 60 km/h; in between there is a range of other speed values. Constant parameters are the time to set-up a vehicle for unloading and the time required to hook/unhook a trailer. A variable parameter is the service time, which depends on the number of pallets to unload. The main restriction is that all the routes must be performed in one day, and the company imposes an extra constraint stating that a vehicle must perform its latest delivery as far as possible from the inventory, since it could be used to perform extra services on its way back. These extra services were not included in the planning by explicit request of the company.

Solution method and results

This planning challenge was modeled as a VRPTW, and solved by an implementation of the MACS-VRPTW algorithm [9], named ANTROUTE. MACS-VRPTW is the most efficient ACO algorithm for the VRPTW and one of the most efficient metaheuristics overall for this problem. ANTROUTE adds to MACS-VRPTW the ability to handle the choice of the vehicle type: at the start of each tour the ant chooses a vehicle. To prevent vehicles arriving too early at the stores a waiting cost was also introduced. The central idea of the MACS-VRPTW algorithm is to use two ant colonies (MACS stands for multi ant colony system) to optimize two objectives: One colony, named ACS-VEI, minimizes the vehicles while the other one, named ACS-TIME, minimizes time.

Human tour planners evaluated the first tours computed by ANTROUTE and the tours were not accepted as feasible, even if the performance was considerably higher than theirs and no explicit constraints were violated. That's the reason why a further modeling step was required, to let "invisible" constraints emerge. One of them was a regional planning strategy, that led to petal shaped tours, as the human planners were currently doing. This way of doing tours was included in the reformulation of the problem, but at the same time the project team tried to loosen the constraint a bit. Stores would be attributed to distribution regions, allowing at the same time stores near the border of the distribution region to also belong to the neighbouring region. This new generation of tours were a bit worse than the unconstrained solution, but nonetheless better than the solutions found by the human planners. Table 2 presents the results obtained by ANTROUTE compared with those of the human planners.

ANTROUTE was run under two scenarios: AR-RegTW, with regional planning and 1-hour time windows; AR-Free, where the regional and the time windows constraints were detached. The challenge was to distribute 52000 pallets to 6800 clients over a period of 20 days. ANTROUTE was run on the available set of orders daily and it took about 5 minutes to find a solution. At the same time, the planners were at work and it took them at least 3 hours to find a solution. After the testing period, the performances of the algorithm and of the planners have been compared using the same objective function. A further advantage of an algorithm able to find the solution to a very hard problem in such a short time is the possibility of using it as a strategic planning tool beside of the operative role. Figure 1 indicates how running the algorithm with wider time-windows at the stores returns a smaller number of tours, which can be interpreted in a significant reduction of transportation costs. The logistic manager can therefore use the optimization algorithm as a tool to check how to re-design the time-windows in the stores.

Major logistics operator: Distribution from factory to inventory stores

In this business case the company is a major logistics operator in Italy. The distribution process comprises moving palletized goods from factories to inventory stores, before they are after distributed to shops. A customer in this vehicle routing problem is either a pick-up or a delivery point. A central depot doesn't exist, and approximately 1000 – 1500 vehicles per day are used.

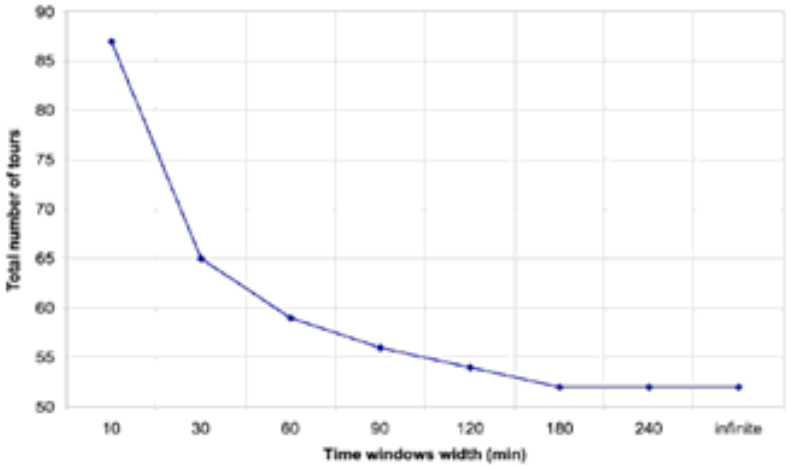

Fig. 1: The relationship between the number of vehicle routes and the time window width.

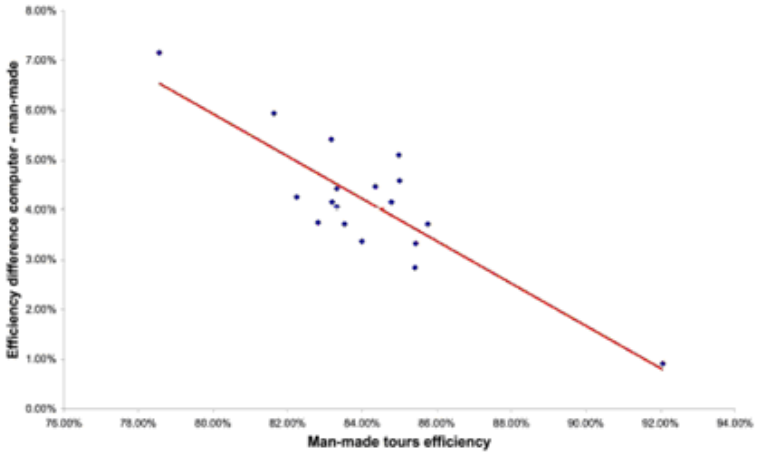

Fig. 2: Comparing man-made and computer-generated tours. Higher efficiency improvements are observed when the human planner performance is lower. The dots are experimental values, and the solid line is a regression on those values.

Because of the geographical constitution of Italy and the strict legal constraint on the maximum number of hours per day that a driver can travel, routes can be performed within the same day, over two days, or over three days. All pick-ups of a tour must happen before deliveries, and orders cannot be split among tours. Further are time windows associated with each store and there is only one type of vehicle: tractor with semi trailer. The load is measured in three units: Pallets, kilograms and cubic meters. Each one of these units has a capacity constraint and the first one that is passed causes the violation of the constraint. Since they are provided by flexible sub-contractors, the availability of trucks is assumed to be infinite. These sub-contractors are distributed all over Italy, and therefore trucks can start their routes from the first assigned customer, and for the company doesn't result any traveling cost to the first client in the route. The road network graph could be found out due to digital road maps, computing the shortest path between each couple of stores. The travel times are calculated according to the travelled distance, given the average speed that can be obtained on each road segment according to its type (highway, extraurban road, urban road).

Further the loading and the unloading times are assumed to be constant parameters, since the company has been unable so far to provide better estimates. Consequently this assumption is a rough approximation imposed by the company, which also imposed another constraint, related to the same problem, setting a maximum number of cities to visit per tour (usually less than six). Note that more than one customer can reside in a city. Furthermore, the company requested that the distance between successive deliveries should be limited by a parameter.

Solution method and results

This planning challenge was modeled as a VRP with pickup and delivery and time windows (VRPPDTW). The objective function quantifies the average tour efficiency. The ANTROUTE algorithm for using in this context has been modified: Since for this problem there is a single objective instead of two (business case before) — to maximise average efficiency — the ant colony minimising the number of vehicles was removed.

	Human Planner	ANTROUTE	Absolute difference	Relative difference
Total nr of tours	471.5	460.8	-10.7	-2.63%
Total km	175441	173623	-1818.2	-1.32%
Efficiency	84.08%	88.27%	+4.19%	-

Tab. 3: Comparison of the man-made vs computer-generated tours in the VRPPDTW application.

Table 3 resumes the comparison between man-made and computer-generated tours over a testing period of two weeks. A significant enhancement in the efficiency of computer-generated tours can be noticed. Another interesting point is to observe how the algorithm performance is correlated with the difficulty of the problem, which is related to the number of orders to satisfy. Figure 2 shows on the x-axis the efficiency of the man-made tours, and on the y-axis the efficiency improvement obtained using the computer-generated tours. When the problem is easy, because it containes a limited number of orders, and the human planner schedules well, the computer is not able to deliver a significative enhancement, but when the planner starts to fail coping with the problem complexity, and the performance falls, the gain in using the algorithm sensibly rises.

Fuel oil distributor: On-line VRP for fuel distribution

This case study treats a fuel oil distribution company in Switzerland, which serves its customers from its main depot located near Lugano with a fleet of 10 trucks. The fuel oil distributor noted that during every Winter season there was always a subset of their customers that ran out of fuel and had to place urgent orders. These unanticipated orders have an impact on the planned delivery routes of the trucks, and the vehicle routing problem becomes very “dynamic”. This means that a considerable percentage of orders must be fulfilled after the trucks have already left the depot. The goal of this case study was to evaluate the impact of a reactive strategy for vehicle routing, starting from data analysis collected in periods when urgent deliveries were in high request. A sample of 50 customers from the company data base was randomly selected and travel times among them were computed. In the company records, customers randomly appeared during the working day with random requests for a quantity of fuel to be supplied.

An 8 hours working day was considered and a service time of 10 minutes for each customer was supposed. The cut-off time was set to 4 hours. Thenceforward the new orders received were deferred to the following working day.

Solution method and results

The problem description above fits the on-line VRP variant, where new orders can be allocated to vehicles which have already left the depot (e.g., parcel collection, feeder systems, fuel distribution, etc.). Montemanni et al. [17] have developed an ACO-inspired algorithm, ACS-DVRP, adapted from the decomposition of the on-line VRP into a sequence of static VRPs. ACS-DVRP solves the on-line fuel oil distribution problem and its algorithm architecture consists of three main elements: the event manager, the ant colony algorithm and the pheromone conservation strategy. The event manager obtains new orders and maintains track of the already served orders and of the position and the remaining capacity of each truck. This information is used to build the sequence of static VRP-like instances. The working day is split into time slices and for each of them a static VRP is created. Every static VRP considers all the already received (but not yet executed) orders. New orders received during a time slice are deferred until its end. At the end of each time slice, customers whose service time starts in the next time slice are assigned to the trucks. They will not be considered in the following static VRPs.

The ant colony algorithm applied based on the MACS-VRPTW implementation, named ANTROUTE, is described in former sections. Instead of two ant colonies there is only one, which is in charge of minimizing the total travel time. Furthermore the pheromone conservation strategy is characterised as follows. Once a time slice is over and the relative static problem has been solved, the pheromone matrix comprised information about good solutions. Since each static problem is potentially very similar to the next one, this information is transferred to the next problem [11]:

if a couple of customers is in both the previous and the current time slice, the pheromone on the arcs connecting two nodes is brought forward as a fragment of its value in the previous problem.

Several test problems were created, where the algorithm ACS-DVRP was applied, due to varying the number n_{ts} of time slices into which the working day was divided. As the size of each problem in a time slice increases as the length of the time slice decreases, the time t_{acs} assigned to executing the ant colony system and the time t_{ls} allocated to local search improving the solution were adapted accordingly. Especially the ratio between t_{acs} and t_{ls} was kept around equal to 10. Table 4 and its first three rows with the values parameters n_{ts}, t_{acs} and t_{ls} define the settings of the experiments. The final row shows the total travel time of the solutions calculated by the ACS-DVRP algorithm. The results show that, for this specific case study, good values for n_{ts} are between 10 and 50. Especially, 25 appears to be the best choice. Large values of n_{ts} did not lead to satisfying results because optimization was restarted too often, before a good local minimum could be obtained. Otherwise, when n_{ts} was too small, the system was not able to take advantage of information on new incoming orders.

n_{ts}	200	100	50	25	10	5
t_{acs}	144	288	576	1152	2880	5760
t_{ls}	15	30	60	120	240	480
Travel time	12702	12422	10399	9744	10733	11201

Tab. 4: Experimental results on the case study of Lugano. n_{ts}: number of time slices into which the working day was divided; t_{acs}: the time allocated to executing the ant colony system; t_{ls}: the time dedicated to local search improving the solution.

Conclusions

This contribution describes the metaheuristic ant colony optimization and how it can be successfully used to solve a number of variants of the basic vehicle routing problem. The main part presents two industrial-scale applications of ACO for the solution of static VRP problems: a VRP with time windows and a VRP with pickup and delivery. Then the contribution focuses its attention on one important dynamic variant of the VRP: the on-line VRP. The problem is receiving increasing attention based on its relevance to real world problems, in particular for distribution in urban environments. The applications of ACO on real-world VRP shows that this metaheuristic inspired by ants has become an important tool in applied operations research.

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About the authors

Dario Coltorti received the Master degree in Business Administration from the University of Berne (lic.rer.pol.), Switzerland in 2005. Since 2005 he is one of the responsible for Business Development of AntOptima, the spin-off company of Swiss research Institute Dalle Molle for Artificial Intelligence (IDSIA). He accelerated the market introduction of innovative optimization products of AntOptima. With AntRoute AntOptima became laureate of Swiss Technology Award 2007 and was invited at the Hannover Fair "get new technology first" 2007 to show the latest and most advanced products for the logistics, transportation and production sector. Meantime AntOptima continued to acquire further European and Swiss customers. One of the latest clients of AntOptima is Kamps, Germany's leading bakery specialist.

Company webpage: www.antoptima.ch
Email: dario.coltorti@antoptima.ch

Dr Andrea E. Rizzoli is a co-founder of AntOptima. Dr Rizzoli is also senior researcher at IDSIA and professor at SUPSI (University of Applied Sciences of Southern Switzerland). He holds a M.Sc. in Control Engineering (1989) and a Ph.D. in Control Engineering and Informatics (1993). His research interests are in modeling and simulation of dynamic systems, in the development of decision support systems for resources management, and in the application of artificial intelligence and operations research techniques to transportation and logistics problems. Dr Rizzoli has authored more than 80 scientific publications. He is editor for informatics of the international journal "Environmental Modelling & Software".

Company webpage: www.antoptima.ch
Email: andrea.rizzoli@antoptima.ch

The XCSF Classifier System in Java

Martin V. Butz, University of Würzburg, Germany, butz@psychologie.uni-wuerzburg.de

After many inquiries by various researchers in the field, I finally got around to completely restructure my XCS Java code released in 2000 (!) and was able to make a new version available. Due the apparent lack of publicly available real-valued XCS implementations and the struggle of many to implement it from scratch, I invested the time and put out a real-valued XCS implementation for function approximation. The code is available from Martin Pelikan's MEDAL lab webpage (http://medal.cs.umsl.edu/files/XCSFJava1.1.zip). It includes the Java API, which should give a general idea of how the code works and how classes communicate with each other. Moreover, there is a short MEDAL report available that gives further code details and also points out what needs to be done to adjust or enhance the code for your individual research needs (http://medal.cs.umsl.edu/files/2007008.pdf). This note is meant to spread the good news and to give a short idea of what the code is capable of.

Code Features

The XCSFJava1.1 code includes most XCSF features published so far. Classifiers consist only of conditions and predictions. Thus, the implementation does not support problems in which more than two classes need to be distinguished — although the necessary enhancements are rather easy to accomplish. Nonetheless, the code can be applied to approximate Boolean functions with two problem classes. That is, it can be tested on the multiplexer problem as well as on any other imaginable binary classification problem — instead of determining an action for classification, though, the XCSF implementation determines only if a problem instance yields high payoff (belonging to class one) or low payoff (class zero). Certainly, though, XCSFJava1.1 is best suited for real-valued function approximation problems. In the real-valued domain, predictions can be optionally generated as constant predictions or linear predictions (linearly dependent on the input), which in turn can be either updated by the (simpler) delta rule or by recursive least squares techniques. XCSFJava1.1 supports hyper-rectangular conditions as well as hyper-spheroid and hyper-ellipsoidal conditions. Besides the different options for the classifier structure, the code also supports classifier population compaction mechanisms [1]. The compaction mechanisms include condensation, in which the GA is applied without mutating or recombining the offspring, closest classifier matching, in which a certain fixed number of classifiers closest to in the problem input match, and an optional greedy compaction algorithm, which does a prioritized sweep over the population typically eliminating more than 90% of the classifiers in the population while only marginally decreasing approximation accuracy. The above options can be conveniently specified in a parameter file — of which a basic version is provided with the code package. The parameters also allow the specification of other setup parameters, including other XCS learning parameters, performance monitoring, and optional visualisations of the learning process. The last feature is the mentioned performance monitoring using visualizations. 2D and 3D visualization of respective problem input space dimensions are supported for hyper-rectangular conditions and most hyper-ellipsoidal condition types. The code shows the classifiers evolving in the problem input space, visualizing the (scaled) location, size, orientation, and fitness of the classifier conditions. Java 3D is used for this feature in 3D input spaces.

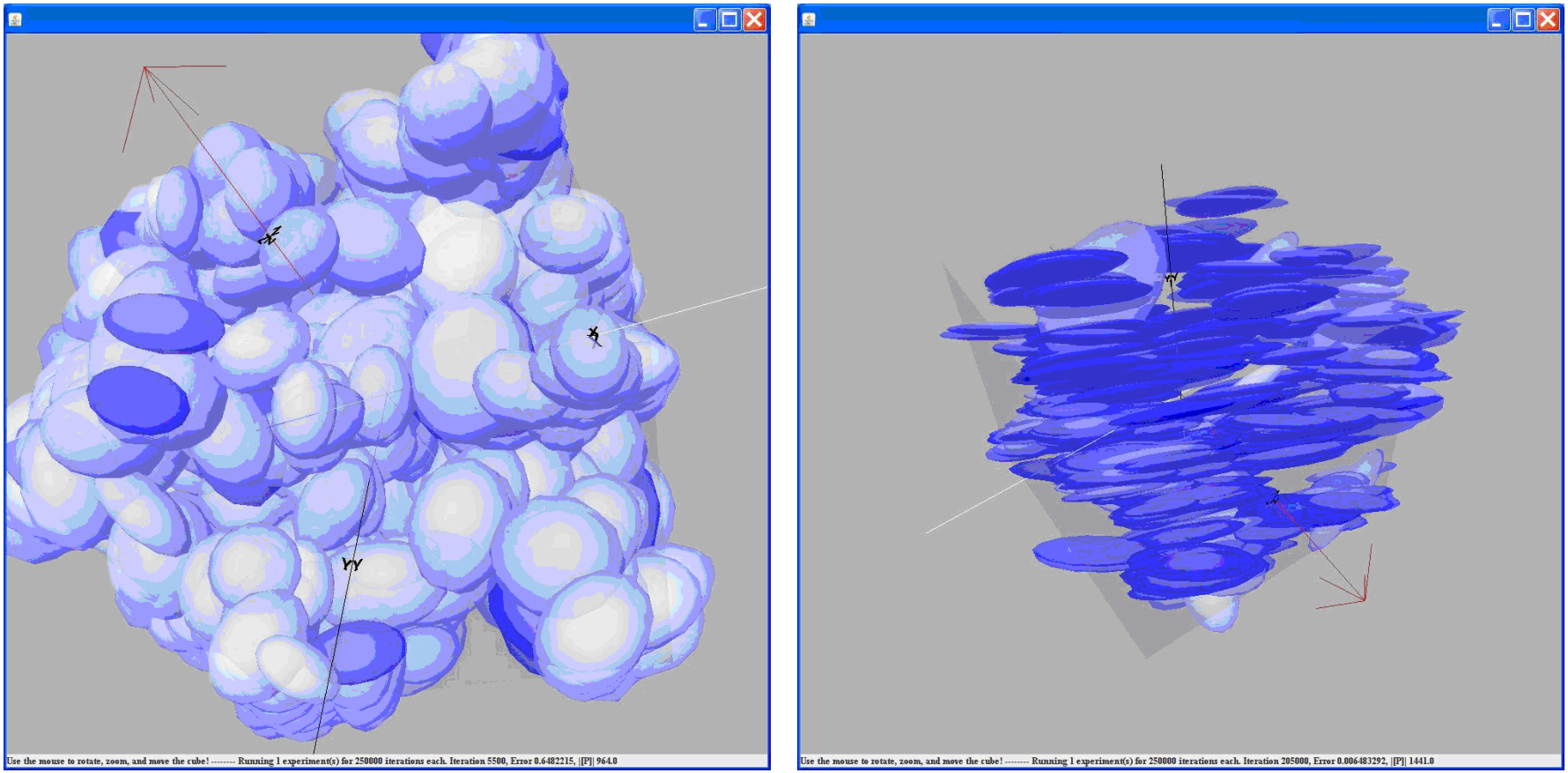

Fig. 1: A population of condition structures early and late during learning. Darker shapes indicate higher fitness. The conditions visualized are 20% of the actual size.

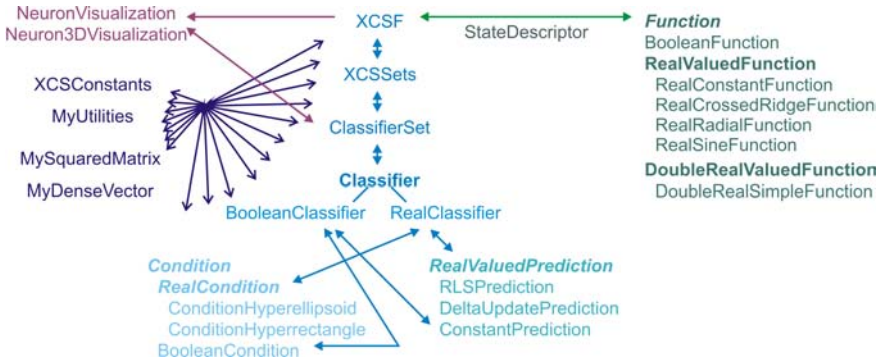

Fig. 2: Overall code structure showing the basic interactions between the classes.

It is possible to either monitor the evolutionary process step-by-step, in which case also the matching and offspring classifiers are highlighted, or to view the evolving population periodically after a specified number of learning iterations. Figure 1 shows two screenshots of the 3D visualization early and late during learning an oblique sine wave function with hyper-ellipsoidal classifier conditions and linear approximations.

Code Structure

Figure 2 gives a general idea of the overall functioning of the code. The `XCSF` class serves as the main executive — generating experimental runs, maintaining performance statistics, and iteratively executing the main learning iterations. `XCSSets` maintains population and current match sets and delegates learning and classification steps to the appropriate classifier sets. `ClassifierSet` implements a classifier set and all XCS-relevant operations on sets including updating, evolutionary component, and classifier additions and deletions. The interface `Classifier` maintains one classifier structure — dependent on the chosen problem a `BooleanClassifier` or a `RealClassifier`, where a Boolean classifier consists of a `BooleanCondition` class object and a `ConstantPrediction` class object whereas a real-valued classifier consists of a `RealCondition` interface object, which can be either of class `CondtionHyperrectangle` or `ConditionHyperellipsoid`, and a `RealValuedPrediction` interface object, which can be of class `ConstantPrediction`, `DeltaUpdatePrediction`, or `RLSPrediction`. Additionally, the `Function` interface realizes the communication with the targeted function approximation problem where problem instances are coded as `StateDescriptor` objects. As current test functions, the `BooleanFunction` class implements a constant Boolean function and the multiplexer function whereas the `RealValuedFunction` implementations can generate a `RealConstantFunction`, a `RealCrossedRidgeFunction`, a `ReadRadialFunction`, or a `RealSineFunction` class object. Multiple parameters allow the further modification of the selected test function's size and complexity. Class `XCSConstants` provides static access to all XCS relevant constants and also supports reading and writing the constants. `MyUtilities` encodes some utilities such as sorting and the determination of a fixed number of closest classifiers. Also the utilized random number generator is located here. Finally, `MySquaredMatrix` and `MyDenseVector` are used as fundamental data structures within various parts of the code.

Final Remarks

The code is publicly available and meant for academic use. While there is no warranty for the code's correctness, it has been intensively tested and evaluated in the provided problem domains confirming its validity. I strongly hope that it is useful for students and teachers alike to get a kick-start in the successful application of XCS to their problem at hand as well as for successful future research studies. Especially the provided visualization options should help to quickly gain a deeper understanding of the general functioning of XCS. Thus, I can only wish everybody good luck with using the code, have fun, and if there are any questions or if bugs are spotted or if you simply like or hate the code for whatever reason, then let me know!

Bibliography

[1] M. V. Butz, P. L. Lanzi, S. W. Wilson. *Function Approximation with XCS: Hyperellipsoidal Conditions, Recursive Least Squares, and Compaction* IEEE Transactions on Evolutionary Computation. (in press).

About the author

Martin V. Butz received his PhD in computer science at the University of Illinois at Urbana-Champaign in October 2004 under the supervision of David E. Goldberg. His thesis "Rule-based evolutionary online learning systems: Learning Bounds, Classification, and Prediction" puts forward a modular, facet-wise system analysis for Learning Classifier Systems (LCSs) and analyzes and enhances the XCS classifier system. Until September 2007, Butz was working at the University of Würzburg at the Department of Cognitive Psychology III on the interdisciplinary cognitive systems project "MindRACES: From reactive to anticipatory cognitive embodied systems". In October 2007 he founded his own cognitive systems laboratory: "Cognitive Bodyspaces: Learning and Behavior" (COBOSLAB), funded by the German research foundation under the Emmy Noether framework. Butz is the co-founder of the "Anticipatory Behavior in Adaptive Learning Systems (ABiALS)" workshop series and is currently also co-organizing the "International Workshop on Learning Classifier Systems" (IWLCS) series. Butz has published and co-edited four books on learning classifier systems and anticipatory systems. Currently, he is focusing on the design of highly flexible and adaptive cognitive system architectures, based on recent research insights gained in cognitive psychology, behavioral neuroscience, evolutionary biology, and adaptive behavior.

Homepage: http://www.psychologie.uni-wuerzburg.de/i3pages/butz
COBOSLAB: http://www.coboslab.psychologie.uni-wuerzburg.de
Email: mbutz@psychologie.uni-wuerzburg.de

Lost Gems of EC

The Equilibrium Genetic Algorithm and the Role of Crossover

Fernando G. Lobo, DEEI-FCT, University of Algarve, Portugal, flobo@ualg.pt

This summer I found a beautiful paper titled *The Equilibrium Genetic Algorithm and the Role of Crossover* [1]. It's from Nov/1993 and is authored by Ari Juels, Shumeet Baluja, and Alistair Sinclair. To my best knowledge, this paper describes the first evolutionary algorithm that explicitly replaces the population by a probability vector. While reading the paper, one can recognize that the main goal of the authors is to come up with an abstraction of the basic genetic algorithm in order to better analyze it from a mathematical perspective. To that end, they develop the *Equilibrium Genetic Algorithm* (EGA), and, as a byproduct, are able to show that some of the mechanisms present in standard genetic algorithms are likely to be, in certain cases, unnecessarily complex.

The EGA is based on two idealizations of the standard GA. The first is the assumption that the population on which the GA operates is infinite. The second is that the crossover phase is repeated an infinite number of times per generation. The work has two major insights: (1) the observation that for any gene position, the proportion of individuals having a given allele value in that position is invariant under any crossover operator, and (2) the repeated application of multiple crossover steps per generation, leads, in the limiting case, to a complete decorrelation of the population's genes, allowing it to be represented by a probability vector $I = (w_1, w_2, \ldots, w_n)$, with each of the w_i denoting the proportion of individuals having allele 1 at gene position i.

The probability vector is denoted as an equilibrium point in an n-dimensional unit hypercube, because it represents the limiting form of the population after an infinite number of crossover steps. Since the allele frequencies are invariant under crossover, and the equilibrium point represents a population that is already "mated to convergence", the crossover operator can be dismissed altogether and its effect obtained by polling the allele frequencies contained in the equilibrium point itself. The algorithm proceeds by sampling a number of solutions from the equilibrium point, evaluating them, and shifting the equilibrium point in the direction of the best sampled individual.

While the EGA work is practically unknown in the EC community (I myself only got to know it this summer), a twin algorithm of it drew a lot of attention. A few months after the EGA was developed, Baluja proposed *Population Based Incremental Learning* (PBIL) [2], as an extension of the EGA. Baluja's technical report does cite Juels' contribution as a personal communication, and recognizes that the standard PBIL is precisely the same thing as the EGA.

Another related algorithm is the *compact GA* [3]. Its major difference with respect to EGA/PBIL is that the compact GA manipulates the probability vector in such a way that it mimics the behaviour of a simple GA operating on a population of a given finite size. Similarly to the compact GA authors, one of the things that I like about the EGA paper is that they don't recommend the resulting algorithm as a powerful optimization method. Instead, they view it as an abstraction of the simple genetic algorithm, and as a *proof of principle* that the standard crossover operators are quite limited. Quoting a paragraph from the paper,

> Nonetheless, our aim is not to advocate the EGA as a necessarily useful optimization technique. On the contrary, the EGA is an extremely naïve algorithm, and we see its success relative to conventional GAs based on bit strings and crossover as potentially highlighting the inherent limitations in these algorithms.

I found Juels' email address on the web and congratulated him for the nice paper. Having noticed that he hasn't been working on GA-related things, I mentioned to him that he is a pioneer of *Estimation of Distribution Algorithms* (EDAs), currently a hot topic in Evolutionary Computation. I also told him it's a pity that he hardly gets any credit for his EGA work. He replied with a nice message saying that he tried several times to publish the paper when he was a graduate student but it was consistently rejected. Then, eventually he started to work on data security and just gave up on it. The material, however, shows up as part of his PhD dissertation in 1996, *Topics in Black-Box Combinatorial Optimization*. He seemed happy to get my email message and told me that it is very encouraging to hear that he was on the right track.

I recommend everyone interested in EDAs (and in evolutionary computation in general) to read the paper. While others had similar ideas, it seems to me that Ari Juels thought about them before anyone else.

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[2] S. Baluja. Population-based incremental learning: A method for integrating genetic search based function optimization and competitive learning. Tech. Rep. No. CMU-CS-94-163, Carnegie Mellon University, Pittsburgh, PA, 1994.

[3] G. R. Harik, F. G. Lobo, and D. E. Goldberg. The compact genetic algorithm. *IEEE Transactions on Evolutionary Computation*, 3(4):287–297, 1999.

About the author

Fernando Lobo received a Masters degree in Computer Science in 1997 from the University of Illinois at Urbana-Champaign and a Ph.D. degree in Environmental Engineering in 2000 from the New University of Lisbon. He has been doing research in evolutionary algorithms since 1995. His major contributions have been in the area of estimation of distribution algorithms and in automated population sizing for genetic algorithms. He is an Assistant Professor at the Department of Electronics and Informatics Engineering at the University of Algarve.

Homepage: http://w3.ualg.pt/ flobo/
Email: fernando.lobo@gmail.com


2008 EVO*
www.evostar.org
Napoli, Italy
26-28 March 2008
EuroGP
11th European Conference
on Genetic Programming
EvoCOP
8th European Conference
on Evolutionary Computation
in Combinatorial Optimisation
EvoBIO
6th European Conference
on Evolutionary Computation,
Machine Learning and
Data Mining in Bioinformatics
EvoWorkshops
European Workshops on the
Theory and Applications of
Evolutionary Computation
Evo* Coordinator
Jennifer Willies
Local Chair
Ivanoe De Falco
Publicity Chair
Anna I Esparcia
Early registration discounts
available from 7th January to
25th February 2008
"Ammonite II", by Dennis H Miller (2004-2005)

Announcements

NERO 2.0 Machine Learning Game

From Risto Miikkulainen, Kenneth Stanley, Igor Karpov, & the NERO development team.

We are pleased to announce the release of NERO 2.0 machine learning game. In this game, the player trains teams of agents to perform complex tasks in a simulated 3D environment. The agents are controlled by neural networks that learn based on the rtNEAT neuroevolution method. The training is evaluated in autonomous battle mode against other teams; the game also provides a territory-control mode for interactive game play. The territory mode is new in 2.0; this release also includes a new user interface and more extensive training tools.

NERO can be downloaded freely from http://nerogame.org for Linux, OS X, and Windows platforms. It is intended to serve three purposes:

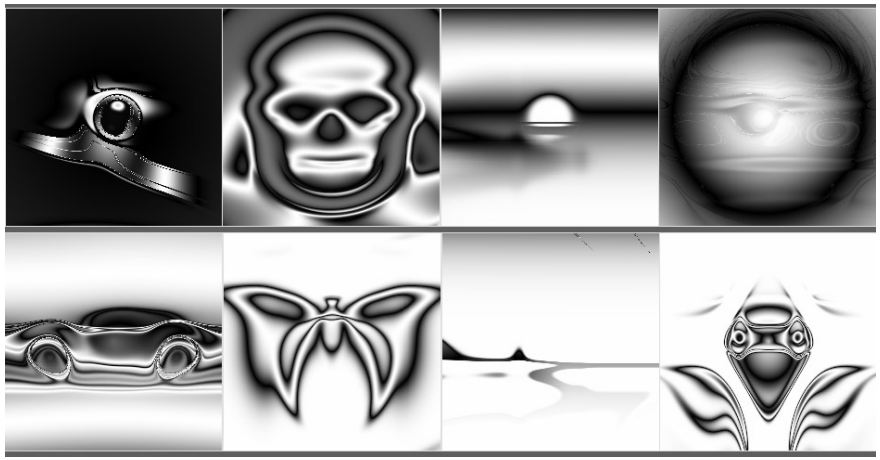
- It is an engaging game that demonstrates a new genre of video games where machine learning plays a central role. The site includes videos illustrating the gameplay and evolved behaviors, and the game includes a tutorial mode that makes it easy to get started.
- It is a "killer application" of rtNEAT, demonstrating how it can be used to learn complex behaviors in real time. For more details on rtNEAT and its application in NERO, see the paper at http://nn.cs.utexas.edu/keyword?stanley:ieeetec05. The rtNEAT (and NEAT) software is available at http://nn.cs.utexas.edu/soft-list.php.
- It is a prototype of a research platform that will allow developing and testing new machine learning methods in a complex video game environment, as well as a demonstration tools for various AI methods in general.

We would like to get your feedback especially on this last point. In the near future, we will put together an open-source version of NERO (v2.0 is based on the Torque game engine) and plan to extend it to serve as a general research platform for the community. How can the NERO environment best support research in machine learning and embedded artificial agents? How can it best serve as a demonstration platform e.g. for AI courses? At this point, we invite you to try out NERO 2.0 and give us feedback and suggestions on how to make OpenNERO a useful such tool for the future.

Picbreeder: Collaborative Interactive Evolution of Artwork

From Kenneth Stanley (kstanley@eecs.ucf.edu)

The Evolutionary Complexity Group (E-plex) (http://eplex.cs.ucf.edu) at the University of Central Florida (http://www.ucf.edu) is pleased to invite the evolutionary computation community to participate in a new interactive website called Picbreeder (http://www.picbreeder.org), which is a large-scale online experiment in Collaborative Interactive Evolution (CIE) of artwork.



Like in other genetic art programs, users evolve images in Picbreeder by selecting ones that appeal to them to produce the next generation. However, Picbreeder goes beyond previous efforts by offering an online community in which to share these images, and most importantly, the ability to continue evolving others' images. As a result, users have been able to evolve genuinely recognizable objects such as faces, cars, and animals, all without any *a priori* knowledge in the system. Please see our recent short publication on Picbreeder for more information:

Picbreeder: Collaborative Interactive Evolution of Images. Jimmy Secretan, Nicholas Beato, David B. D'Ambrosio, Adelein Rodriguez, Adam Campbell and Kenneth O. Stanley In: Leonardo (Transactions Section) Vol. 41, No. 1 (2007)

New Journal: Evolutionary Intelligence

From Larry Bull (Larry.Bull@uwe.ac.uk)

Evolutionary Intelligence is a new quarterly journal devoted to the publication and dissemination of theoretical and practical aspects of the use of population-based search for artificial intelligence. Techniques of interest include evolving rule-based systems, evolving artificial neural networks, evolving fuzzy systems, evolving Bayesian and statistical approaches, artificial immune systems, and hybrid systems which combine evolutionary computation with other A.I. techniques in general. The first issue is due to appear in January 2008. More details can be found here: www.springer.com/12065.

Tenure-Track Faculty Positions in Computer Science at University of Missouri - Rolla

From Daniel R. Tauritz (tauritzd@umr.edu)
Department of Computer Science
University of Missouri - Rolla
http://cs.umr.edu/

The Department of Computer Science at the University of Missouri-Rolla is seeking outstanding applicants for tenure-track faculty positions, preferably at the level of Assistant Professor. The department concentrates its research efforts in the following three areas: 1) Critical Infrastructure Protection, 2) Software Engineering, and 3) Bioinformatics. The successful candidate will be expected to contribute to the departmental research efforts in one or more of these areas and to have commitment to quality teaching both at the undergraduate and graduate levels. Applicants must have a demonstrated record of research publication, funding potential, and evidence of quality teaching commensurate with the position they seek. Applicants should hold a Ph.D. in Computer Science or a closely related field by the appointment start date.

The Department has 17 full-time faculty positions including a recently established endowed chair, with some joint appointments in Computer Engineering, and grants the BS, MS, and Ph.D. degrees.

The Department has a cohesive faculty with rapidly growing levels of funded research. Opportunities for interdisciplinary research abound and such activities are strongly encouraged with several campus-wide research centers. Researchers at the University of Missouri-Rolla will benefit from close collaborations with industrial partners, a science and technology park established by the university to attract high-tech industry, and from a generous intellectual property policy. Salary is competitive with Big-10/Big-12 universities.

The University of Missouri-Rolla is the primary science and engineering campus of the University of Missouri system. It draws an excellent student population with the incoming freshman class in the top 10% of the nation. Its 284-acre campus is situated amid the scenic rolling hills of the Ozarks and near some of the Missouri's most beautiful spring-fed creeks, caves, and other natural formations. Rolla, a community of about 17,000 residents, was named one of the best small towns in America according to Crampton's The 100 Best Small Towns in America. The cosmopolitan city of St. Louis and its international airport are within easy driving distance, and many recreational opportunities are near by.

Interested applicants should send 1) a vita, 2) a statement of research and teaching interests, 3) any supplementary evidence of research, teaching, and communication skills, and 4) three letters of reference to:

Human Resource Services Reference Numbers: 00031155 & 00030659
University of Missouri-Rolla 1870 Miner Circle Rolla, MO 65409-1050
hrsinfo@umr.edu

The committee will begin reviewing applications in January 2008. Applications will be accepted until the positions are filled, with appointments expected to start August 2008.

UMR is an AA/EEO employer. Females, minorities, and persons with disabilities are encouraged to apply. Effective January 1, 2008, UMR becomes Missouri University of Science and Technology (Missouri S&T)

New Books

Natural Computing Series

- Bandyopadhyay and Pal, "Classification and Learning Using Genetic Algorithms" (WWW)
- Böckenhauer and Bongartz, "Algorithmic Aspects of Bioinformatics" (WWW)
- Blum and Merkle, "Swarm Intelligence" (WWW)
- Knowles et al., "Multiobjective Problem Solving from Nature" (WWW)
- Romero and Machado, "The Art of Artificial Evolution" (WWW)
- Siarry and Michalewicz, "Advances in Metaheuristics for Hard Optimization" (WWW)
- Eiben and Smith, "Introduction to Evolutionary Computing", corrected reprint (WWW)

Other Volumes

- Miranda, "Evolutionary Computer Music" (WWW)
- Michalewicz et al., "Adaptive Business Intelligence (WWW)
- Hecht-Nielsen, "Confabulation Theory - The Mechanism of Thought" (WWW)
- Manoonpong, "Neural Preprocessing and Control of Reactive Walking Machines" (WWW)
- Patnaik, "Robot Cognition and Navigation" (WWW)
- Barbieri, "Introduction to Biosemiotics" (WWW)
- Érdi, "Complexity Explained" (WWW)
- Goertzel and Pennachin, "Artificial General Intelligence" (WWW)

Genetic and Evolutionary Computation Series

- Coello Coello et al., "Evolutionary Algorithms for Solving Multi-objective Problems" (WWW)
- Riolo et al., "Genetic Programming Theory and Practice IV" (WWW)
- Riolo et al., "Genetic Programming Theory and Practice V" (WWW)
- Brameier and Banzhaf, "Linear Genetic Programming" (WWW)
- Goldberg and Sastry, "Genetic Algorithms - The Design of Innovation", 2nd ed. (WWW)

Studies in Computational Intelligence

- Yu et al., "Evolutionary Computation in Practice" (WWW)
- Brabazon and O'Neill, "Natural Computing in Computational Finance" (WWW)
- Ghosh et al., "Multi-objective Evolutionary Algorithms for Knowledge Discovery from Databases" (WWW)
- Yang et al., "Evolutionary Computation in Dynamic and Uncertain Environments" (WWW)
- Yang et al., "Success in Evolutionary Computation" (WWW)
- Abraham et al., "Engineering Evolutionary Intelligent Systems" (WWW)
- Grosan et al., "Hybrid Evolutionary Algorithms" (WWW)
- Lobo et al., "Parameter Setting in Evolutionary Algorithms" (WWW)
- Pelikan et al., "Scalable Optimization via Probabilistic Modeling" (WWW)

Lecture Notes in Computer Science
Special Volumes or Selected Postproceedings

- Butz et al., Anticipatory Behavior in Adaptive Learning Systems, LNCS 4520 (WWW)
- Kovacs et al., Learning Classifier Systems, LNCS 4399 (WWW)
- Lungarella et al., "50 Years of Artificial Intelligence", LNCS 4850 (WWW)
- Brueckner et al.,"Engineering Self-organising Systems", LNCS 4335 (WWW)
- Sahin et al., Swarm Robotics, LNCS 4433 (WWW)

Lecture Notes in Computer Science
Conference Proceedings

- Bartz-Beielstein, Hybrid Metaheuristics, HM 2007, LNCS 4771 (WWW)
- Obayashi et al., EMO 2007, LNCS 4403 (WWW)
- Almeida e Costa, ECAL 2007, LNCS 4648 (WWW)
- Ebner et al., EuroGP 2007, LNCS 4445 (WWW)
- Giacobini et al., EvoWorkshops 2007, LNCS 4448 (WWW)
- Cotta and van Hemert, EvoCOP 2007, LNCS 4446 (WWW)
- Marchiori et al., EvoBIO 2007, LNCS 4447 (WWW)
- Stephens et al., FOGA 2007, LNCS 4436 (WWW)

Forthcoming Papers

Genetic Programming and Evolvable Machines 8(3) (www)

- **A note on the variance of rank-based selection strategies for genetic algorithms and genetic programming**, Artem Sokolov, Darrell Whitley and André da Motta Salles Barreto, pp 221–237 (pdf) doi: 10.1007/s10710-007-9030-1
- Where is evolutionary computation going? A temporal analysis of the EC community, Carlos Cotta and Juan-Julián Merelo, pp 239–253 (pdf) doi: 10.1007/s10710-007-9031-0
- **A self-organizing random immigrants genetic algorithm for dynamic optimization problems**, Renato Tinós and Shengxiang Yang, pp 255–286 (pdf) doi: 10.1007/s10710-007-9024-z

Genetic Programming and Evolvable Machines 8(4) (www)

- **Introduction to the special issue on medical applications of Genetic and Evolutionary Computation**, Stephen L. Smith and Stefano Cagnoni, pp 297–299 (pdf) doi: 10.1007/s10710-007-9037-7
- **An evolutionary approach to cancer chemotherapy scheduling**, Gabriela Ochoa, Minaya Villasana and Edmund K. Burke, pp 301–318 (pdf) doi: 10.1007/s10710-007-9041-y
- **Interactive evolution for cochlear implants fitting**, Pierrick Legrand, Claire Bourgeois-Republique, Vincent Péan, Esther Harboun-Cohen, Jacques Levy-Vehel, Bruno Frachet, Evelyne Lutton and Pierre Collet, pp 319–354 (pdf) doi: 10.1007/s10710-007-9048-4
- **Stochastic optimization of a biologically plausible spino-neuromuscular system model: A comparison with human subjects**, Stanley Gotshall, Kathy Browder, Jessica Sampson, Terence Soule and Richard Wells, pp 355–380 (pdf) doi: 10.1007/s10710-007-9044-8
- **Using evolvable genetic cellular automata to model breast cancer**, Armand Bankhead and Robert B. Heckendorn, pp 381–393 (pdf) doi: 10.1007/s10710-007-9042-x
- **Genomic mining for complex disease traits with "random chemistry"**, Margaret J. Eppstein, Joshua L. Payne, Bill C. White and Jason H. Moore, pp 395–411 (pdf) doi: 10.1007/s10710-007-9039-5
- **Genetic programming for computational pharmacokinetics in drug discovery and development**, Francesco Archetti, Stefano Lanzeni, Enza Messina and Leonardo Vanneschi, pp 413–432 (pdf) doi: 10.1007/s10710-007-9040-z
- **Diagnosis of Parkinson's disease using evolutionary algorithms**, Stephen L. Smith, Patrick Gaughan, David M. Halliday, Quan Ju, Nabil M. Aly and Jeremy R. Playfer, pp 433–447 (pdf) doi: 10.1007/s10710-007-9043-9

Evolutionary Computation 15(3) (www)

- **Agent-Based Model of Genotype Editing** , Chien-feng Huang, Jasleen Kaur, Ana Maguitman, and Luis M. Rocha, pp 253–290
- **Covariant Genetic Dynamics** , Chryssomalis Chryssomalakos and Christopher R. Stephens, pp 291-320
- **Crossover and Evolutionary Stability in the Prisoner's Dilemma**, Xavier Thibert-Plante and Paul Charbonneau, pp 321–344
- **A New Approach of Data Clustering Using a Flock of Agents**, Fabien Picarougne, Hanene Azzag, Gilles Venturini, and Christiane Guinot, pp 345–368
- **A Graph-Based Evolutionary Algorithm: Genetic Network Programming (GNP) and Its Extension Using Reinforcement Learning** Shingo Mabu, Kotaro Hirasawa, and Jinglu Hu, pp 369–398

Evolutionary Computation 15(4) (www)

- **Speeding Up Evolutionary Algorithms through Asymmetric Mutation Operators**, Benjamin Doerr, Nils Hebbinghaus, and Frank Neumann, pp 401–410
- **Comparison-Based Algorithms Are Robust and Randomized Algorithms Are Anytime**, Sylvain Gelly, Sylvie Ruette, and Olivier Teytaud, pp 411–434
- **A Note on Problem Difficulty Measures in Black-Box Optimization: Classification, Realizations and Predictability**, Jun He, Colin Reeves, Carsten Witt and Xin Yao, pp 435–474
- **Geometric Crossovers for Multiway Graph Partitioning**, Alberto Moraglio, Yong-Hyuk Kim, Yourim Yoon, and Byung-Ro Moon, pp 445–474
- **On the Hardness of Offline Multi-objective Optimization**, Olivier Teytaud, pp 475–492
- **Pareto-adaptive ε-dominance**, Alfredo G. Hernández-Díaz, Luis V. Santana-Quintero, Carlos A. Coello Coello, Julián Molina, pp 493–516

Evolutionary Intelligence 1(1) (www)

- **Foreword**, Dedication - Lawrence J. Fogel
- **Neuroevolution: from architectures to learning**, D. Floreano, P. Durr & C. Mattiussi
- **Learning Classifier Systems: Then and Now**, P-L. Lanzi
- **Genetic Fuzzy Systems: Taxonomy, Current Research Trends and Prospects**, F. Herrera
- **An Interdisciplinary Perspective on Artificial Immune Systems**, J. Timmis, P. Andrews, N. Owens & E. Clark

Swarm Intelligence 13(1) (www)

- **Editorial**, Marco Dorigo, pp 1–2 (pdf)
  doi: 10.1007/s11721-007-0003-z
- **The biological principles of swarm intelligence**, Simon Garnier, Jacques Gautrais and Guy Theraulaz, pp 3–31 (pdf)
  doi: 10.1007/s11721-007-0004-y
- **Particle swarm optimization: An overview**
  Riccardo Poli, James Kennedy and Tim Blackwell, pp 33–57 (pdf)
  doi: 10.1007/s11721-007-0002-0
- **Mathematical runtime analysis of ACO algorithms: survey on an emerging issue**, Walter J. Gutjahr, pp 59–79 (pdf)
  doi: 10.1007/s11721-007-0001-1

Calls and Calendar

December 2007

Genetic Programming and Evolvable Machines
Special Issue on Evolutionary Computation in Games
Guest editors: Moshe Sipper (www), Mario Giacobini (www).
Submission Deadline December 31, 2007
Notification of review results: March 1, 2008
Final manuscript: May 1, 2008

During the past few years there has been an ever-increasing interest in the application of evolutionary algorithms within the vast domain of games. This special issue aims to present a selection of top papers in the field. Topics include (but are not limited to) evolutionary computation in:

- Board games (e.g., checkers, Go, chess)
- Imperfect information and non-deterministic games
- Video games
- Real-time strategy games
- Game avatars
- Non-player characters and game agents
- Games involving control of physical objects
- Games with simulated physics
- Prey / Predator games (e.g., Pacman)
- Game protocols (e.g., protocols for game-playing over the web)
- "Real-world" games (e.g., share trading, portfolio management)
- General architectures and algorithms for game agents and non-player characters
- Long-term learning and skill transference in game agents
- Games for education and training
- Social/biological/cultural modeling games

All enquiries about this special issue should be sent to the guest editors. Prospective authors are invited to send an email to the guest editors indicating their interest in submitting a paper and the specific topics addressed.

IEEE Transactions on Evolutionary Computation
Special issue on Swarm Intelligence
Guest editors: Dr Xiaodong Li, Professor Andries Engelbrecht, Professor Luca Gambardella and Professor Martin Middendorf.
Submission Deadline December 31, 2007
Notification of the first-round review: March 31, 2008
Expected publication: beginning of 2009
Homepage: WWW

Swarm Intelligence (SI) is an Artificial Intelligence technique involving the study of collective behaviour in decentralized systems. Such systems are made up by a population of simple individuals interacting locally with one another and with their environment. Although there is typically no centralized control dictating the behaviour of the individuals, local interactions among the individuals often cause a global pattern to emerge. Examples of systems like this can be found abundant in nature, including ant colonies, bird flocking, animal herding, honey bees, bacteria, and many more. SI refers to the problem-solving behaviour that emerges from the interaction between individuals of such systems, and computational swarm intelligence refers to algorithmic models of such behaviors. These algorithmic models have shown to be able to adapt well in changing environments, and are immensely flexible and robust. As traditional algorithms, which emphasize more on 'centralization', become increasingly inadequate in handling today's more complex problems, SI algorithms offer an attractive alternative to problem solving. The last decade has shown rapid growing research interests in SI, as demonstrated by the significant increase of the number of research publications on SI, especially on two popular SI paradigms, namely Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO).

Authors are invited to submit their original and unpublished work in the areas including (but not limited to) the following:

- Theoretical studies of SI paradigms and algorithms
- Development of new SI paradigms and algorithms
- SI algorithms for multi-objective optimization
- SI algorithms for constrained optimization
- SI algorithms for niching and multi-modal optimization
- SI algorithms for optimization in dynamic and noisy environments
- SI algorithms for evolving artificial neural networks
- SI algorithms for games and learning
- Hybrids between SI algorithms and other heuristic methods
- Comparative theoretical and empirical studies
- Benchmarking and evaluation of new SI algorithms
- Self-adaptive SI algorithms
- SI algorithms for real-world applications
- Nature-inspired algorithms based on collective behaviors
- Swarm robotics and other SI-inspired systems

Important Dates

- Authors Notification: December 01, 2007
- Notification of the first-round review: March 31, 2008
- Revised submission due: June 30, 2008
- Final notice of acceptance/reject: August 31, 2008
- Final manuscript: September 30, 2008

March 2008

EuroGP 2008 - Eleventh European conference on Genetic Programming

March 26–28, 2008. Napoli, Italy

Homepage: http://www.evostar.org

EuroGP is the premier conference in Europe devoted entirely to genetic programming. We invite high quality submissions on all aspects of evolutionary generation of computer programs featuring new original research. A double-blind review process will be adopted. The conference will feature a mixture of oral presentations and poster sessions. The EuroGP conference is always a very enjoyable event offering excellent opportunities for networking, informal contact, exchange of ideas and discussions with fellow researchers in a friendly and relaxed setting. High quality papers are sought on topics strongly related to the evolution of computer programs, ranging from theoretical work to innovative applications.

Topics include but are not limited to

- Theoretical developments
- Empirical studies of GP performance and behavior
- Algorithms, representations and operators
- Applications of GP to real-life problems
- Hybrid architectures including GP components
- Unconventional evolvable computation
- Evolutionary design
- Evolutionary robotics
- Grammar-based GP
- Evolvable hardware
- Linear GP
- Self-reproducing programs
- Evolution of tree or graph structures
- Evolution of various classes of automata or machine
- Object-oriented genetic programming

EvoCOP 2008 - Eighth European Conference on Evolutionary Computation in Combinatorial Optimisation

March 26–28, 2008. Napoli, Italy

Homepage: http://www.evostar.org

Metaheuristics have often been shown to be effective for difficult combinatorial optimization problems appearing in various industrial, economical, and scientific domains. The EvoCOP series, started in 2001 and held annually since then, was the first event specifically dedicated to the application of evolutionary computation and related methods to combinatorial optimization problems. Following the general trend of hybrid metaheuristics and diminishing boundaries between the different classes of metaheuristics, EvoCOP has broadened its scope and now explicitly invites submissions on any kind of metaheuristic for combinatorial optimization. The past events gave researchers a good opportunity to present their latest research and to discuss current developments and applications, besides stimulating closer future interaction between members of this scientific community. EvoCOP 2008 wants to bring researchers in the field of metaheuristics together once again. Each accepted papers will be presented orally at the conference and printed in the proceedings published by Springer in the LNCS series.

Topics include:

- Applications of metaheuristics to combinatorial optimization problems
- Representation techniques
- Neighborhoods and efficient algorithms for searching them
- Variation operators for stochastic search methods
- Constraint-handling techniques
- Hybrid methods and hybridization techniques
- Parallelization
- Theoretical developments
- Search space analyses
- Comparisons between different (also exact) techniques

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- Hybrid methods and hybridization techniques
- Parallelization
- Theoretical developments
- Search space analyses
- Comparisons between different (also exact) techniques

EvoWorkshops 2008 - European Workshops on the Theory and Applications of Evolutionary Computation

March 26–28, 2008. Napoli, Italy

Homepage: http://www.evostar.org

Coordinator: Mario Giacobini - mario.giacobini@unito.it

- **EvoCOMNET**: Fifth European Workshop on the Application of Nature-inspired Techniques to Telecommunication Networks and other Connected Systems
- **EvoFIN**: Second European Workshop on Evolutionary Computation in Finance and Economics
- **EvoHOT**: Fourth European Workshop on Bio-Inspired Heuristics for Design Automation
- **EvoIASP**: Tenth Workshop on Evolutionary Computation in Image Analysis and Signal Processing
- **EvoMUSART**: Sixth European Workshop on Evolutionary and Biologically Inspired Music, Sound, Art and Design
- **EvoNUM**: First European Workshop on Bio-inspired algorithms for continuous parameter optimisation
- **EvoPhD**: Third European Graduate Student Workshop on Evolutionary Computation
- **EvoSTOC**: Fifth European Workshop on Evolutionary Algorithms in Stochastic and Dynamic Environments
- **EvoTHEORY**: First European Workshop on Theoretical Aspects in Artificial Evolution
- **EvoTransLog**: Second European Workshop on Evolutionary Computation in Transportation and Logistics

May 2008

Genetic Programming Theory and Practice 2008

May 15-17 (Thur-Sat), 2008 Ann Arbor Michigan USA

Deadline January 11, 2008

The Center for the Study of Complex Systems (CSCS) at the University of Michigan is pleased to be hosting: GPTP-2008 – Sixth Annual Genetic Programming Theory and Practice Workshop May 15-17 (Thur-Sat), 2008 Ann Arbor Michigan USA

GPTP is a small, one-track, invitation-only workshop devoted to the integration of theory and practice. In particular, it focuses on how theory can inform practice and what practice reveals about theory. Past workshops have invited speakers to discuss theoretical work and its value to practitioners of the art, and to review problems and observations from practice that challenge existing theory. This year we are asking researchers who are interested in being invited to present a paper at this Workshop to submit an abstract representing the work they would like to present. We will extend a limited number of invitations to participate based on these abstracts. We especially encourage papers which combine theory with results from real-world applications, e.g., papers in which theory is used to guide application to real-world problems, and/or results from real-world applications that confirm (or contradict) theory. In this vein, collaborations between "theorists" and "practitioners" are most welcome, since such collaborations are quite rare but they are likely to lead to new insights and novel results.

Some of the questions this workshop is expected to address include:

- Does the schema (or other analogous) theorem hold for GP, and what does this mean for the design and use of GP applications?
- What are good ways to approach the application of GP to a new problem? What are good ways to adjust control parameters within GP? Are there heuristics to guide the choice of representation, search operators, and so on?
- What are the "symptoms" of GP pathology (i.e., premature convergence, overfitting, etc.)?
- How universal is the behavior of GP over different problems and data types?
- What are the good and bad features of GP for problem application?

- Are there ways to predict whether a problem is "GP tractable?"
- Application of GP to "real" problems, e.g., applications with large amounts of noisy data, or applications in which GP must compete with other more accepted approaches.

If you are interested in having a paper considered for presentation at the workshop and included in the book, please send a one-page abstract as well as a short CV of the authors to: gptp-2008@umich.edu by: 11 January 2008. Earlier responses are encouraged.

The abstracts will be reviewed and decisions made by 18 January 2008. We will select 6-8 proposed papers based on relevance to the GPTP workshop goals, the expected quality of the contribution, and how the paper topic will fit with the "mix" of other invited and selected papers. If you do anticipate sending an abstract, please let us know as soon possible, just so we have a rough idea of how many abstract to expect.

June 2008

2008 IEEE World Congress on Computational Intelligence

June 1-6, 2008, Hong Kong

Homepage: WWW

Deadline December 1, 2007

The 2008 IEEE World Congress on Computational Intelligence (WCCI 2008) will be held at the Hong Kong Convention and Exhibition Centre during June 1-6, 2008. Sponsored by the IEEE Computational Intelligence Society, co-sponsored by the International Neural Network Society, Evolutionary Programming Society and the Institution of Engineering and Technology, WCCI 2008 is composed of the 2008 International Joint Conference on Neural Networks (IJCNN 2008), the 2008 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2008) and the 2008 IEEE Congress on Evolutionary Computation (CEC 2008). WCCI 2008 will be the fifth milestone in this series with a glorious history from WCCI 1994 in Orlando, WCCI 1998 in Anchorage, WCCI 2002 in Honolulu, to WCCI 2006 in Vancouver.

Call for Contributed Papers

Researchers are invited to contribute high-quality papers to WCCI 2008. All papers are to be submitted electronically through the Congress website by December 1, 2007.

All submitted papers will be refereed by experts in the fields based on the criteria of originality, significance, quality, and clarity. For inquiries, contact IJCNN2008 Program Chair Derong Liu, FUZZ-IEEE2008 Program Chair Gary Feng, or CEC2008 Program Chair Zbigniew Michalewicz.

Call for Special Sessions

WCCI 2008 Program Committees solicit proposals for special sessions within the technical scopes of the three conferences. Special sessions, to be organized by internationally recognized experts, aim to bring together researchers in special focused topics. Cross-fertilization of the three research areas of computational intelligence with new emerging technologies is strongly encouraged. Papers submitted for special sessions are to be peer-reviewed with the same criteria used for the contributed papers. Researchers interested in organizing special sessions are invited to submit formal proposals to IJCNN2008 Special Sessions Chair Jagath C. Rajapakse at? asjagath@ntu.edu.sg, FUZZ-IEEE2008 Special Sessions Chair Xiao-Jun Zeng at x.zeng@manchester.ac.uk, CEC2008 Special Sessions Chair Yuhui Shi at shi@ieee.org, or Special Sessions Chair on Emerging Areas Byoung-Tak Zhang at btzhang@bi.snu.ac.kr by November 1, 2007. A special session proposal should include a proposed session title, a brief description of the scope and motivation, biographic and contact information of the organizer(s).

Call for Tutorials and Workshops

WCCI 2008 will also feature pre-congress tutorials and post-congress workshops covering fundamental and advanced computational intelligence topics. A tutorial proposal should include title, outline, expected enrollment, and presenter biography. Any inquires regarding the tutorials should be addressed to Tutorial Chairs Wlodzislaw Duch at wduch@is.umk.pl, Russell Eberhart at reberhar@iupui.edu, and Qiang Shen at qqs@aber.ac.uk by January 1, 2008. Any inquires regarding the workshops should be addressed to Workshops Chairs Irwin K.C. King at king@cse.cuhk.edu.hk and Yangmin Li at ymli@umac.mo by January 1, 2008.

Call for Competitions

WCCI 2008 will host competitions to stimulate research in computational intelligence, promote fair evaluations, and attract students. The proposals should include descriptions of the problems addressed, motivations and expected impact on computational intelligence, data description, evaluation procedures and established baselines, schedules, anticipated number of participants, and a biography of the main team

members. Proposals are invited to be sent to Competitions Chairs Isabelle Guyon at isabelle@clopinet.com for IJCNN2008, Leszek Rutkowski at rutko@kik.pcz.czest.pl for FUZZ-IEEE2008, or Philip Hingston at p.hingston@ecu.edu.au for CEC2008 by October 1, 2007.

Important Due Dates:

- Competition Proposal: October 1, 2007
- Special Session Proposal: November 1, 2007
- Paper Submission: December 1, 2007
- Tutorial/workshop Proposal: January 1, 2008
- Decision Notification: February 1, 2008
- Camera-Ready Submission: March 1, 2008

More information can be found at http://www.wcci2008.org

July 2008

GECCO 2008 - Genetic and Evolutionary Computation Conference
July 12-16, 2008, Atlanta, Georgia, USA
Homepage: http://www.sigevo.org/gecco-2008
Deadline January 16, 2008
Author notification: March 12, 2008
Camera-ready: April 16, 2008

The GECCO-2008 Program Committee invites submissions for full technical papers for GECCO-2008, to be held in Atlanta, Georgia, USA, July 12-16, 2008. Submissions are invited on substantial, original, and previously unpublished research on all aspects of genetic and evolutionary computation. Each paper submitted to GECCO will be rigorously reviewed, in a double-blind review process, meaning that reviewers should not be able to infer the identities of the authors of the papers under review, and, of course, that authors will not know the identities of their reviewers.

One of at least 16 separate and independent program committees specializing in various aspects of genetic and evolutionary computation review submitted papers.These committees make their own final decisions on submitted papers for their areas, subject only to conference-wide space limitations and procedures. Review criteria includes significance of the work, novelty, clarity, writing quality, and sufficiency of information to permit replication, if applicable.

GECCO notifies the first-named author (or other corresponding author designated by the authors at submission) whether the submission is accepted as an 8-page full paper, 2-page poster abstract, or not accepted by March 12, 2008.

Submission Requirements

The deadline for submitting papers is Wednesday, January 16, 2008.

Meet the Submission Deadline: The deadline for ARRIVAL of submissions is Wednesday, January 16, 2008.

Submit paper to the Review System to be provided. The registered user has a login and password, and is the contact about any paper registered by the user. If you registered on the site and submitted a paper to GECCO 2006 or 2007, your account is still active. To retrieve your password for that account, click the "Forget password?" link, which is to the right of the Login button.

Submit substantially new work: The material in a paper must represent substantially new work that has not been previously published by conferences, journals, or edited books in the genetic and evolutionary computation field. GECCO allows submissions of material that is substantially similar to a paper being submitted contemporaneously for review in another conference. However, if the submitted paper is accepted by GECCO, the authors agree that substantially the same material will not be published by another conference in the evolutionary computation field. Material may be later revised and submitted to a journal, if permitted by the journal.

Submit an ACM-formatted PDF of the paper to the online Review System by the deadline, Wednesday, January 16, 2008. Submissions received after the deadlines, or that do not meet the length, ACM formatting, or anonymous author requirements will not be accepted for review. If there are problems with the electronic submission, gecco-admin will contact the registered user by email. If a registered user believes there is a problem with a submission, the user should contact the Track Chair.

Accept Author Agreement: By submitting a paper, the author(s) agree that, if their paper is accepted, they will:

- Submit a final, revised, camera-ready version by the deadline for camera-ready papers: Wednesday, April 16, 2008
- Complete a paid conference registration for at least one author by Friday, April 18, 2008

- Attend the conference (at least one author).
- Present the accepted paper at the conference.

Best Paper Awards Each track chair will nominate the best papers from their track for "Best Paper of GECCO Awards". GECCO attendees will select the best papers by ballot during the conference.

September 2008

PPSN 2008 - Parallel Problem Solving from Nature

September 13-17, 2008, Dortmund, Germany

Homepage: http://www.ppsn2008.org/ Call for paper: download

Deadline April 14, 2008

PPSN X will showcase a wide range of topics in Natural Computing including, but not restricted to: Evolutionary Computation, Quantum Computation, Molecular Computation, Neural Computation, Artificial Life, Swarm Intelligence, Artificial Ant Systems, Artificial Immune Systems, Self-Organizing Systems, Emergent Behaviors, and Applications to Real-World Problems.

Paper Presentation

Following the now well-established tradition of PPSN conferences, all accepted papers will be presented during small poster sessions of about 16 papers. Each session will contain papers from a wide variety of topics, and will begin by a plenary quick overview of all papers in that session by a major researcher in the field. Past experiences have shown that such presentation format led to more interactions between participants and to a deeper understanding of the papers. All accepted papers will be published in the Proceedings.

Paper Submission

Researchers are invited to submit original work in the field of natural computing as papers of not more than 10 pages. Authors are encouraged to submit their papers in LaTeX. Papers must be submitted in Springer Verlag's LNCS style through the conference homepage, here.

ICES 2008 - 8th International Conference of Evolvable Systems: From Biology to Hardware

September 21-24, 2008. Prague, Czech Republic

Homepage: http://www.fit.vutbr.cz/events/ices2008

Deadline March 19, 2008

Notification of acceptance: April 30, 2008

Camera-ready deadline: May 30, 2008

The 8th International Conference of Evolvable Systems (ICSE 2008) which will be held in Prague, September 21-24, 2008. Topics to be covered include, but are not limited to:

- Evolutionary hardware design
- Evolutionary circuit diagnostics and testing
- Self-reconfiguring/repairing and fault tolerant systems
- Co-evolution of hybrid systems
- Generative and developmental approaches
- Embryonic hardware
- Hardware/software co-evolution
- Intrinsic and extrinsic evolution
- Real-world applications of evolvable hardware
- On-line hardware evolution
- MEMS and nanotechnology in evolvable hardware
- Evolutionary robotics
- Formal models for bio-inspired hardware systems
- Adaptive computing
- Novel devices/testbeds/tools for evolvable hardware

Prospective authors are cordially invited to submit original papers using the electronic submission form on the conference web page. Papers should be written in English with a twelve page maximum in the LNCS format. Please identify the contact author with complete contact information. All accepted papers will be included in the conference proceedings.

Sixth International Conference on Ant Colony Optimization and Swarm Intelligence

September 22–24, 2008. Brussels, Belgium

Homepage: http://iridia.ulb.ac.be/ants2008/

Deadline March 16, 2008

Swarm intelligence is a relatively new discipline that deals with the study of self-organizing processes both in nature and in artificial systems. Researchers in ethology and animal behavior have proposed many models to explain interesting aspects of social insect behavior such as self-organization and shape-formation. Recently, algorithms inspired by these models have been proposed to solve difficult computational problems.

An example of a particularly successful research direction in swarm intelligence is **ant colony optimization**, the main focus of which is on discrete optimization problems. Ant colony optimization has been applied successfully to a large number of difficult discrete optimization problems including the traveling salesman problem, the quadratic assignment problem, scheduling, vehicle routing, etc., as well as to routing in telecommunication networks. Another interesting approach is that of **particle swarm optimization**, that focuses on continuous optimization problems. Here too, a number of successful applications can be found in the recent literature. **Swarm robotics** is another relevant field. Here, the focus is on applying swarm intelligence techniques to the control of large groups of cooperating autonomous robots.

ANTS 2008 will give researchers in swarm intelligence the opportunity to meet, to present their latest research, and to discuss current developments and applications.

The three-day conference will be held in Brussels, Belgium, on September 22–24, 2008. Tutorial sessions will be held in the mornings before the conference program.

ANTS 2008 solicits contributions dealing with any aspect of swarm intelligence. Typical, but not exclusive, topics of interest are:

- Behavioral models of social insects or other animal societies that can stimulate new algorithmic approaches.
- Empirical and theoretical research in swarm intelligence.
- Application of swarm intelligence methods, such as ant colony optimization or particle swarm optimization, to real-world problems.
- Theoretical and experimental research in swarm robotics systems.

Publication Details

Conference proceedings will be published Springer in the LNCS series, as those of the last three editions of the ANTS Conference. The journal *Swarm Intelligence* will publish a special issue dedicated to ANTS 2008 that will contain extended versions of the best research works presented at the conference. Further details will soon be published on the web site.

Best Paper Award

A best paper award will be presented at the conference. Continuing the tradition of the ANTS Conference Series, the prize winner will receive a sculpture of an ant expressly created for the ANTS Conference by the Italian sculptor Matteo Pugliese.

Further Information

Up-to-date information will be published on the web site http://iridia.ulb.ac.be/ants2008/. For information about local arrangements, registration forms, etc., please refer to the above-mentioned web site or contact the local organizers at the address below.

Conference Address

ANTS 2008
IRIDIA CP 194/6
Université Libre de Bruxelles
Av. F. D. Roosevelt 50
1050 Bruxelles, Belgium

Tel +32-2-6502729
Fax +32-2-6502715
http://iridia.ulb.ac.be/ants2008
email: ants@iridia.ulb.ac.be

Important Dates

Submission deadline	March 16, 2008
Notification of acceptance	May 16, 2008
Camera ready copy	May 30, 2008
Conference	September 22–24, 2008

About the Newsletter

SIGEVOlution is the newsletter of SIGEVO, the ACM Special Interest Group on Genetic and Evolutionary Computation.

To join SIGEVO, please follow this link [WWW]

Contributing to SIGEVOlution

We solicit contributions in the following categories:

Art: Are you working with Evolutionary Art? We are always looking for nice evolutionary art for the cover page of the newsletter.

Short surveys and position papers: We invite short surveys and position papers in EC and EC related areas. We are also interested in applications of EC technologies that have solved interesting and important problems.

Software: Are you are a developer of an EC software and you wish to tell us about it? Then, send us a short summary or a short tutorial of your software.

Lost Gems: Did you read an interesting EC paper that, in your opinion, did not receive enough attention or should be rediscovered? Then send us a page about it.

Dissertations: We invite short summaries, around a page, of theses in EC-related areas that have been recently discussed and are available online.

Meetings Reports: Did you participate to an interesting EC-related event? Would you be willing to tell us about it? Then, send us a short summary, around half a page, about the event.

Forthcoming Events: If you have an EC event you wish to announce, this is the place.

News and Announcements: Is there anything you wish to announce? This is the place.

Letters: If you want to ask or to say something to SIGEVO members, please write us a letter!

Suggestions: If you have a suggestion about how to improve the newsletter, please send us an email.

Contributions will be reviewed by members of the newsletter board.

We accept contributions in LaTeX, MS Word, and plain text.

Enquiries about submissions and contributions can be emailed to editor@sigevolution.org.

All the issues of SIGEVOlution are also available online at www.sigevolution.org.

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