SIGEVOlution

newsletter of the ACM Special Interest Group on Genetic and Evolutionary Computation

Volume 9
Issue 4

Cover image: this image "Ghost of Christmas Future" was evolved by the user burndirt using the Evolutionary Art software Picbreeder developed at the University of Central Florida. Image has been modified for design purposes.

in this issue

Editorial

Christmas is approaching fast, and with it, conference deadlines are looming! GECCO's deadline for abstracts is January 30th, with February 6th for full papers, and CEC's deadline is January 16th. Both EMO and EvoSTAR's deadlines have now passed, so good luck to authors waiting to hear about papers they have submitted. A calendar of EC related events is below and you can find the full list of tracks running at GECCO inside this issue.

You will also find an article from Michael Phelan on his PhD research using Grammatical Evolution in Supply Chains called "Bullwhips & Beer: Grammatical Evolution in Supply Chains!". This research is a stepping stone on a path to drive supply chain modelling innovations, building on existing work in biologically-inspired algorithms and supply chain optimisation. It provides a technique rich in potential avenues of exploration that has practical relevance to supply chain decision makers. The primary research question underpinning this work which uses Grammatical Evolution (GE) to find human readable rules asks if GE can provide managerial insights and cost effective heuristics for supply chain optimisation across a range of realistic scenarios. The results demonstrate the flexibility of GE as a supply chain optimisation tool and also its ability to adapt to the objective of each scenario, delivering cost effective ordering policies. The grammars incorporating domain knowledge consistently generate the best supply chain ordering policies.

You can also see highlights of the current Winter Issue of Evolutionary Computation, which is a Special Issue dedicated to Combinatorial Optimisation. The latest publications from Genetic Programming and Evolvable Machines are also highlighted. Finally, on the subject of journals, I'm sure most readers are aware that Hans-Georg Beyer will be retiring from his role as EiC of Evolutionary Computation at the end of the month, and I will take over from January 1st. I'd like to thank Hans-Georg for all his hard work over the past 6 years and for steering the journal towards its current excellent state of health, with an impact factor of 3.6 and ranking 5th out of 111 in Computational Mathematics in the recently published CiteScore rankings.

Happy Christmas and best wishes for 2017!

Emma Hart

Calendar of EC-related activities

12–15 January, 2017, Copenhagen, Denmark: The 14th ACM/SIGEVO Workshop on Foundations of Genetic Algorithms (FOGA XIV)

19–21 April, 2017, Amsterdam, The Netherlands: Evostar 2017

5–9 June, 2017, San Sebastian, Spain: IEEE Conference on Evolutionary Computation (CEC 2017)

15-19 July, 2017, Berlin, Germany: Genetic and Evolutionary Computation Conference (GECCO 2017)

Bullwhips & Beer: Grammatical Evolution in Supply Chains! by Michael Phelan

Summary

Over the last 30 years, the field of supply chain management has received widespread attention from researchers and practitioners across a broad range of disciplines. During this time companies have moved from centrally controlled supply chains towards the outsourcing of non-core functions, requiring new and innovative approaches to how these supply chains are optimised.

In recent years there has been a growing literature in the area of Biologically Inspired Algorithms (BIAs), particularly Genetic Algorithms (GA) and Genetic Programming (GP) and their applications to supply chain modelling and inventory control optimisation. Due to the rigidity of the GAs approach, it is difficult to change the underlying model logic and consequently difficult to add richness to the supply chain. While the application of GP provides a more flexible approach than that provided by GAs, to date its application has been limited to small supply chain modelling problems in relation to optimal inventory policies.

This article presents a brief overview of the PhD research completed by the author under the supervision of Dr. Seán McGarraghy, University College Dublin. It is the first published research to employ Grammatical Evolution (GE), a relatively new BIA in computer science to the field of supply chain optimisation, employing human readable rules called grammars. These grammars provide a single mechanism to describe a variety of complex structures and can incorporate the domain knowledge of the practitioner to bias the algorithm towards regions of the search space containing better solutions.

The primary research question underpinning this work asks if GE can provide managerial insights and cost effective heuristics for supply chain optimisation across a range of realistic scenarios. A comprehensive set of 360 experiments (over 19 billion time series) were run and divided into 11 experimental groups testing the robustness and adaptability of the algorithm across a range of supply chain scenarios. On the experimental evidence obtained this research demonstrated the flexibility of GE as a supply chain optimisation tool and also its ability to adapt to the objective of each scenario, delivering cost effective ordering policies. The grammars incorporating domain knowledge consistently generate the best supply chain ordering policies.

Combining this powerful optimisation approach with more realistic models and incorporating their own domain knowledge, practitioners can develop grammars to bias the GE algorithm towards finding better supply chain ordering policies. The experiments demonstrated that GE can deliver a range of solutions for the same problem, enabling practitioners to compare and contrast policies, highlighting questions that impact on the underlying supply chain strategy. However, it is left up to the expertise of the supply chain practitioner to analyse the managerial implications of these policies.

Grammatical Evolution

Evolutionary Algorithms (EA) have been used to generate other languages using a grammar definition of the target language. GE is an EA developed by O'Neill and Ryan (2003) that can evolve computer programs, sentences in any language or for the purpose of this research: supply chain ordering policies for the Beer Game (see below). Unlike GP where solutions are represented as syntax trees, in GE a linear genome representation is used in conjunction with a grammar. Similar to GP, each individual or genotype is a variable length binary string that contains codons (groups of 8 bits) used to select production rules from the grammar.

The language or in this case supply chain ordering policies to be generated, are described using a Backus Naur Form (BNF) grammar definition, consisting of a series of production rules mapping non-terminal symbols to the terminals which appear in the language. BNF is a notation for expressing the grammar of a language, or in this example, ordering policies, in the form of production rules. BNF grammars consist of terminals, which are items that can exist in the language, e.g. +, -, *, / etc., and non-terminals, which can be expanded into one or more terminals or non-terminals.

The GE system is inspired by the biological process of generating a protein from the genetic material of an organism. Proteins are responsible for traits such as eye colour or height and are fundamental to the development and operation of all living organisms. For a more detailed discussion of the biological analogy the reader is referred to O'Neill and Ryan (2003) and Brabazon and O'Neill (2006). Figure 1 compares the mapping process employed by both GE and biological organisms.

The binary string of GE is analogous to the double helix of DNA, each guiding the formation of the phenotype. In GE this occurs with the application of production rules from a BNF grammar to generate the terminals of the program or ordering policy. In biological terms the phenotypic protein is determined by the order and type of protein subcomponents (amino acids) that are joined together.

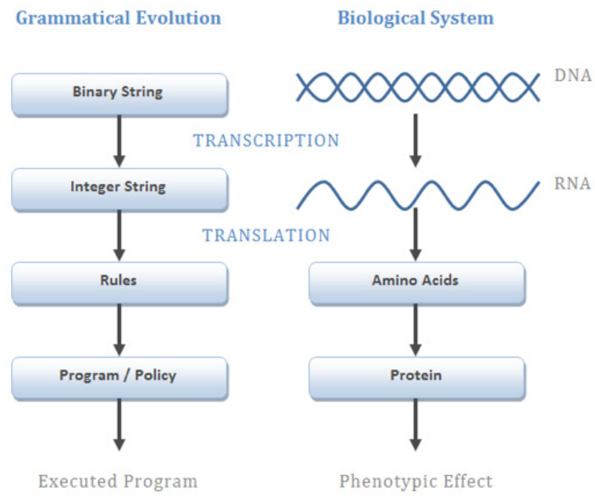


Fig 1 - Comparison of GE system and biological genetic system

Any search engine that can operate on binary or integer strings could employ GE's mapping process to generate a program or policy. As part of this work, particle swarms and Quantum Inspired GA's were also used for the GE search engine.

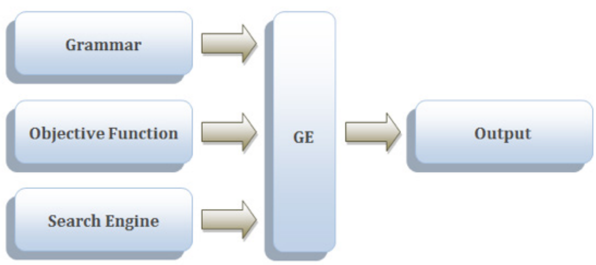


Fig 2 - Overview of the modular structure of Grammatical Evolution employed for this research

Supply Chain Management

The field of Supply Chain Management (SCM) was first coined over 30 years ago and in that time has received widespread attention from researchers and practitioners alike across a broad range of disciplines, each attempting to optimise the profit and minimise the cost to the overall supply chain. A supply chain is a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the downstream flow of materials from supplier to customer and the upstream flow of information originating with end customer demand.
In this time the industrial world has seen unprecedented changes in technology from the internet to software solutions that can design supply chain structures, Enterprise Resource Planning systems and forecasting software to name but a few, that strive to improve the efficiency of these supply chains.

As the concept of supply chain management was taking hold companies were traditionally vertically aligned where a single organisation controlled all levels of their supply chain in a centralised structure. In centralised supply chains, organisations could monitor and share all levels of information throughout the facilities in their chains, promoting the shared goal of cost minimisation across the supply chain.
But during the 1980s there was a significant shift towards outsourcing manufacturing facilities to lower cost economies initially in Europe and then Asia. In margin-challenged sectors like the PC industry, companies have outsourced their production requirements to contract manufacturers in lower cost countries and created globalised supply chains where predicting customer demand months in advance is critical to the success of their company. The lower cost of outsourcing can also have significant downsides as Cisco discovered in 2001 resulting in $2.5 billion inventory write off due to poor coordination with its contract manufacturers and inability to quickly react to a downturn in demand. To realise the cost benefits achieved by these decentralised supply chains requires new innovative approaches to how these supply chains are optimised. Given the vast complexity of modern supply chains, research continues to identify potential tools & techniques to reduce costs across the supply chain including but not limited to inventory control and forecasting optimisation.

One area that receives particular attention is a supply chain phenomenon commonly known as the Bullwhip Effect. The Bullwhip Effect is where orders to a supplier in the supply chain have a larger variance than sales to the buyer in the same supply chain, referred to as demand distortion. This distortion then propagates upstream (from customer to manufacturer) in the supply chain in an amplified form known as variance amplification. The demand distortion implies that an upstream manufacturer in the supply chain only has order visibility from their immediate downstream customer and will be misled by amplified demand patterns. This amplification can dramatically increase the further upstream a partner is in a supply chain and was named after the way the amplitude of a whip increases down its length once cracked. The further away from the source (i.e., hand cracking the whip), the greater the distortion of the wave pattern at the tip of the whip.

The term Bullwhip Effect (also known as the Forrester effect, whiplash or whipsaw effect) was coined by Procter & Gamble after an investigation of one of their bestselling product lines – Pampers nappies. Following an initial investigation they found some demand fluctuations in their retail stores but the variability was low, as they expected, given the steady predictable consumption rate of nappies and steady birth rates. As they examined upstream partners in the supply chain they found that there was a larger degree of variability in the ordering patterns between upstream partners: the further upstream, the larger the variance. Hewlett-Packard also discovered a similar trend in one of its printer lines where there were expected levels of fluctuations in reseller demand over time but the further upstream they examined, the larger the swings in order variability. The Bullwhip Effect is not a new phenomenon in supply chains: evidence of its existence has been recorded as far back as 1919 in the Procter & Gamble supply chain.

In modern supply chain management, research into the Bullwhip Effect has been pioneered by Jay W. Forrester in the USA and Jack Burbidge in the UK. In the late 1950s Jay Forrester applied his expertise in electrical engineering to the domain of human systems, developing the field known today as System Dynamics. In his book Industrial Dynamics, Forrester demonstrated through his production-distribution system that small changes to this naturally oscillating system can have serious impacts on its operation (i.e., the Bullwhip Effect). Forrester also pioneered the simulation approach and demonstrated the importance of linking information flow with material flow. In keeping with this philosophy, the System Dynamics team at MIT developed a supply chain management simulation known as the Beer Distribution Game or Beer Game.

In the classic version of the Beer Game, customer demand is 4 cases of beer per week for the first 4 weeks, followed by 8 cases for the remainder of the game (players are told the game will run for 50 simulated weeks but play is halted around 36 weeks to avoid any horizon effects). The basic setup and weekly operation of the Beer Game is as follows: (1) shipments arrive from upstream players, (2) orders arrive from downstream players, (3) orders are filled and shipped where possible affecting the inventory on-hand and backorders (unfulfilled orders) of a player, (4) the player decides how much to order to replenish their inventory and finally (5) inventory holding costs (typically \$0.50 per case of beer per week) and backorder costs (typically \$1.00 per case of unfulfilled demand per week) are calculated for each player every week & values recorded on an information sheet.

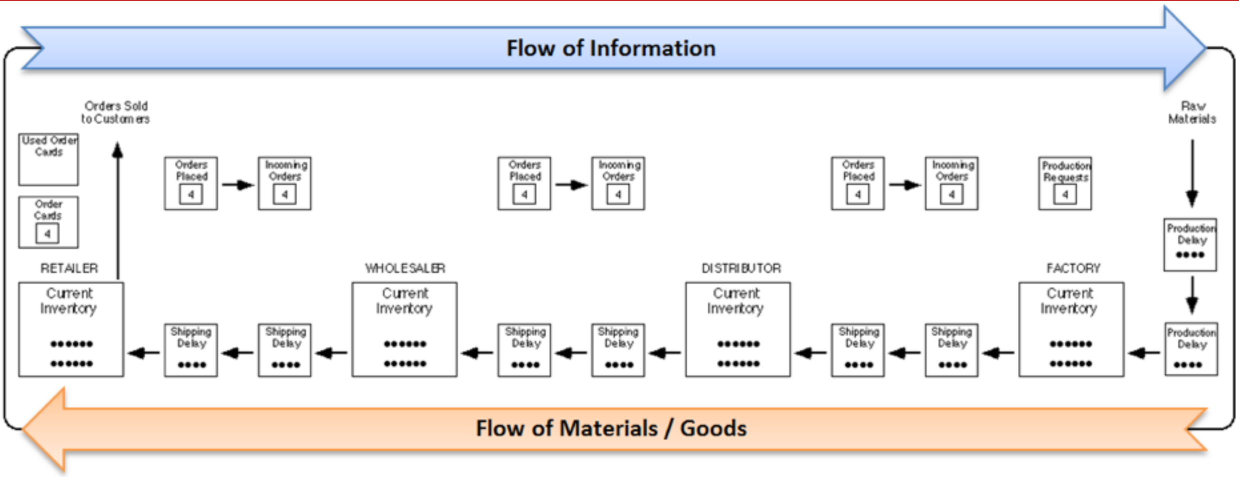


Fig - Beer Distribution board game initial setup

The only decision any player has to make while playing the Beer Game is what order to place with their immediate upstream supplier at the end of every round (week), the other operations are merely accounting and progressing material & information delays in the supply chain.
The Beer Game is widely used in industry to demonstrate the existence of the Bullwhip Effect in a simplified supply chain setting where the simple rules and limited decisions during each round of the game can have a dramatic impact on inventory & backorder levels across the supply chain.

The author is currently leading the DePuy Synthes (medical device companies of Johnson & Johnson) Supply Chain IT Data Science Group working on supply chain inventory & forecasting analytics employing simulation, GA & GE algorithms to address the evolving requirements of their global supply chain.
Within the DePuy Synthes Global Supply Chain (GSC) group based in Cork, Ireland, a modified version of the Beer Game is played with supply chain practitioners. Recently the GSC hosted a Beer Game style tournament (Joints Production Distribution Game) where the rules, setup & costs mirrored those of the classic Beer Game. As expected, a similar story unfolded during the course of the game where the Bullwhip Effect made a strong appearance and the typical pattern of high levels of backorders followed by inventory stockpiles (see Figure 3) caused consternation with the players but all in good fun (after the game was over). A typical debriefing session after the Beer Game will ask Factory & Wholesaler players what they thought the actual customer demand was (as seen by the Retailer) & accusations abound until the real demand pattern and player actions are revealed and discussed.

Fig 4 - DePuy Synthes Global Supply Chain group playing the Beer Game

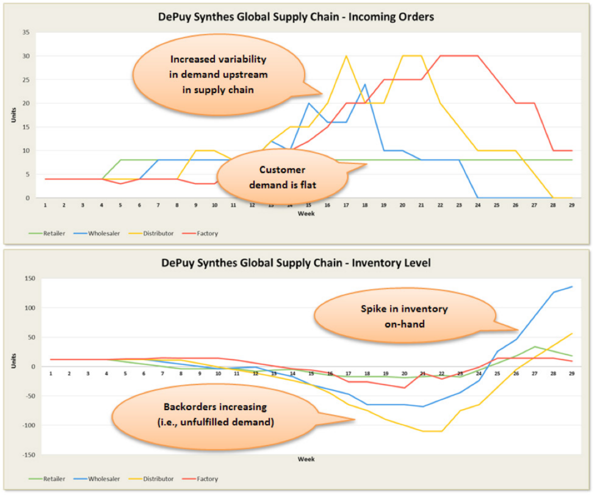


Fig 5 - Beer Game Incoming Orders & Inventory Levels

Application of Biologically Inspired Algorithms to Supply Chain Management

Since the millennium there has been a growing literature in the area of BIAs and supply chain optimisation most notably GAs, GP & the GE approach described in this research. Using these approaches artificial agents act in the place of the supply chain partners or facilities evolving supply chain ordering policy heuristics that minimise the total cost of the overall supply chain. The Beer Game is commonly employed (being an intractable 23rd order non-linear difference equation & sufficiently complex) to evaluate the fitness of potential supply chain heuristic ordering strategies aimed at minimising the overall supply chain cost. An early contribution in this area is the application of GAs by Steven Kimbrough et al. (2002) to evolve supply chain ordering policies for each player in the Beer Game (i.e., Retailer, Wholesaler, Distributor & Factory) that minimises the overall supply chain cost. The policies in question are an “X+Y” type policy, i.e., if a player (e.g., Retailer) receives an order from their customer for X units in any given week, that player places an order for X+Y units at the end of the week to their immediate upstream supplier (i.e., Wholesaler) where Y can be a negative (where the minimum order is zero, i.e., Max{0, X-Y}) or a positive integer value [0, 31]. The encoding strategy comprises of a 24 bit binary string where each agent’s ordering policy is 6 bits long with the first bit denoting plus or minus and the remaining 5 bits representing an integer value [0, 31] (i.e., 2^5-1). Employing this approach where the classic Beer Game is used to evaluate the fitness or each genotype, the GA found the optimal supply chain strategy was for every agent to

order X+0 (i.e., simply order the same number of units as your incoming order). This ordering strategy mitigates the Bullwhip Effect and maintains lower costs in the supply chain.
GE has also been successfully employed to mitigate the Bullwhip Effect in the Beer Game and given a basic grammar file (Grammar 1), GE evolved a strategy of the form X-(X-8), i.e., order the mean demand of 8 units per week every week for all Beer Game agents which is supported by forecasting theory on stationary data.

```
<agent>  ::= <policy><policy><policy><policy>
<policy> ::= <var>|<var><op><int>|<policy><op>(<var><op><int>)
<op>     ::= +|-
<int>    ::= 0|1|2|3|4|5|6|7|8|9|10|11|12|13|14|15|16|17|18|19|20
<var>    ::= x
```

Grammar 1 - Beer Game Ordering Policy

Figure 6 shows the comparison of the ordering strategy employed by the DePuy Synthes Global Supply Chain team (a typical result when played in a company setting) and the costs associated with the GA X+Y policy and the GE mean demand policy. While the Beer Game is a very simplified supply chain, it is interesting to compare the different ordering strategies and gain a valuable insight into what these strategies can tell us about the interaction of supply chain agents.

Fig 6 - Comparison of total supply chain costs associated with different ordering strategies in the Beer Game

Given the significant problems the Bullwhip Effect can cause in supply chains (e.g., inventory stockpiles due to over production, labour & materials shortages due to unmet demand etc.) and coupled with the complexity of modern decentralised supply chains, innovative heuristic approaches to reduce the Bullwhip Effect are more important than ever to maintain competitive supply chains driving customer costs down while maintaining sustainable profit margins. The application of evolutionary algorithms to supply chain management and bullwhip mitigation is an exciting area of research with new tools & techniques being developed and evaluated.

The core theme of this research is the need to incorporate more real world supply chain concepts into the supply chain modelling domain. In doing so, the supply chain models become more complex and less tractable, requiring new and innovative techniques to optimise these models. This research is a stepping stone on the path to drive these supply chain modelling innovations, building on the existing work in BIAs and supply chain optimisation, and providing a technique, rich in potential avenues of exploration that have practical relevance to supply chain decision makers.

Recommended Reading

- Phelan, M. and McGarraghy, S., 2016. Grammatical evolution in developing optimal inventory policies for serial and distribution supply chains. International Journal of Production Research, 54(1), pp.336-364.
- Phelan, M. and McGarraghy, S., 2007. Mitigating the Bullwhip Effect in Supply Chains using Grammatical Evolution. In Proceedings of the 25th International Conference of the System Dynamics Society (pp. 135-152).
- O'Neill, M. and Ryan, C., 2003. Grammatical Evolution. Springer US.
- Brabazon, A., O'Neill, M. and McGarraghy, S., 2015. Natural Computing Algorithms. Springer-Verlag.
- Brabazon, A. and O'Neill, M., 2006. Biologically inspired algorithms for financial modelling. Springer Science & Business Media.
- Kimbrough, S.O., Wu, D.J. and Zhong, F., 2002. Computers play the beer game: can artificial agents manage supply chains?. Decision support systems, 33(3), pp.323-333.
- O'Donnell, T., Maguire, L., McIvor, R. and Humphreys, P., 2006. Minimizing the bullwhip effect in a supply chain using genetic algorithms. International Journal of Production Research, 44(8), pp.1523-1543.
- O'Reilly, U.M., Yu, T., Riolo, R. and Worzel, B. eds., 2006. Genetic programming theory and practice II (Vol. 8). Springer Science & Business Media.
- Forrester, J., 1961. Industrial dynamics. Vol. 2. MIT press Cambridge, MA
- Lee, H.L., Padmanabhan, V. and Whang, S., 1997. The bullwhip effect in supply chains. MIT Sloan Management Review, 38(3), p.93.
- Sterman, J.D., 1989. Misperceptions of feedback in dynamic decision making. Organizational behavior and human decision processes, 43(3), pp.301-335.

Biography of Author

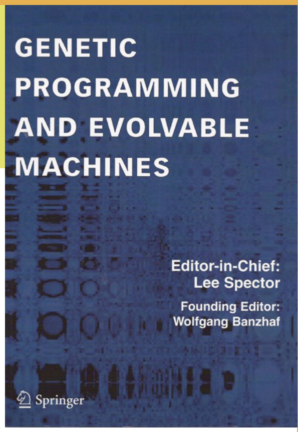
Michael Phelan

Dr. Michael Phelan has been working in Supply Chain Analytics for over 14 years, with a Masters in Management Science (now Business Analytics) and a PhD in Supply Chain Optimisation (under the supervision of Dr. Seán McGarraghy) from the Smurfit Graduate Business School, University College Dublin. During this time, he published in several international peer reviewed journals and books and presented at international conferences in USA, Europe & Asia. He has lectured masters & undergraduate students in analytics and supervised award winning masters supply chain projects.

Michael also has extensive experience in industry working & consulting for large scale multinationals in electronics and medical device sectors in demand & business planning, analytics and IT. Prior to joining DePuy Synthes (medical device companies of Johnson & Johnson), he led a multi-million-dollar technology transformation program for the TSC Group (ANZ) aimed at re-establishing the business post a troubled receivership period. This successful transformation led to the acquisition of the group by Engie, one of the world's leading energy providers and was one of the keynote events at the FSM 2015 conference in Sydney.

He joined DePuy Synthes in 2015 as IT & Analytics Manager and is currently leading the Supply Chain IT Data Science Group developing a team of data scientists, employing diagnostic & advanced analytics to supply chain problem solving.

GENETIC PROGRAMMING AND EVOLVABLE MACHINES



From the Editor's Blog

The fourth issue of Volume 17 of Genetic Programming and Evolvable Machines is now available for download. It contains:

A two-objective memetic approach for the node localization problem in wireless sensor networks
Mahdi Aziz, Mohammad-H Tayarani-N & Mohammad R. Meybodi

Dynamic feedback neuro-evolutionary networks for forecasting the highly fluctuating electrical loads
Gul Muhammad Khan & Faheem Zafari

Prediction of expected performance for a genetic programming classifier
Yuliana Martínez, Leonardo Trujillo, Pierrick Legrand & Edgar Galván-López

Evolution of sustained foraging in three-dimensional environments with physics*
Nicolas Chaumont & Christoph Adami

*Abstract
Artificially evolving foraging behavior in simulated articulated animals has proved to be a notoriously difficult task. Here, we co-evolve the morphology and controller for virtual organisms in a three-dimensional physical environment to produce goal-directed locomotion in articulated agents. We show that following and reaching multiple food sources can evolve de novo, by evaluating each organism on multiple food sources placed on a basic pattern that is gradually randomized across generations. We devised a strategy of evolutionary "staging", where the best organism from a set of evolutionary experiments using a particular fitness function is used to seed a new set, with a fitness function that is progressively altered to better challenge organisms as evolution improves them. We find that an organism's efficiency at reaching the first food source does not predict its ability at finding subsequent ones because foraging efficiency crucially depends on the position of the last food source reached, an effect illustrated by "foraging maps" that capture the organism's controller state, body position, and orientation. Our best evolved foragers are able to reach multiple food sources over 90 % of the time on average, a behavior that is key to any biologically realistic simulation where a self-sustaining population has to survive by collecting food sources in three-dimensional, physical environments.

Important Information

Submit abstracts
(full papers only)
Jan 30, 2017
Submit full papers
Feb 6, 2017
Submit poster-only papers
Feb 6, 2017
Conference
Berlin: July 15-19, 2017
Twitter Stream
@GECCO2017

Local Information

Berlin, the German capital, is renowned for its exceptional variety of attractions, its flourishing cultural scene and a way of life that's both fast-paced and relaxed.

Berlin is a world city of culture, politics, media and science. Contrasts between historical buildings and modern architecture, between the traditional and the modern are what set the city apart from the rest.

Program Tracks

ACO-SI - Ant Colony Optimization and Swarm Intelligence
Xiaodong Li, Martin Middendorf

CS - Complex Systems (Artificial Life/ Artificial Immune Systems/Generative and Developmental Systems/ Evolutionary Robotics/Evolvable Hardware)
Risto Miikkulainen, Emma Hart

DETA - Digital Entertainment Technologies and Arts
Ekart Aniko, Daniele Loiacono

ECOM - Evolutionary Combinatorial Optimization and Metaheuristics
Holger Hoos, Sébastien Verel

EML - Evolutionary Machine Learning
Mengjie Zhang, Will Browne

EMO - Evolutionary Multiobjective Optimization
Tea Tušar, Carlos M. Fonseca

ENUM - Evolutionary Numerical Optimization
Nikolaus Hansen, Marcus Gallagher

GA - Genetic Algorithms
Dirk Thierens, Alberto Moraglio

GECH - General Evolutionary Computation and Hybrids
Jim Smith, Jürgen Branke

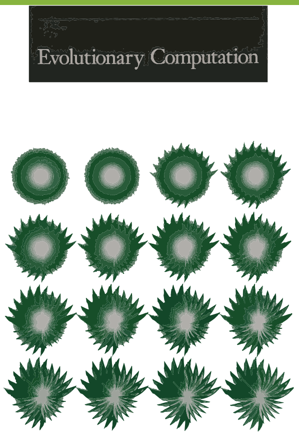
GP - Genetic Programming
Sara Silva, Zdenek Vasicek

RWA - Real World Applications
Anna I Esparcia-Alcázar, Boris Naujoks

SBSE - Search-Based Software Engineering
Simon Poulding, Federica Sarro

THEORY - Theory
Carola Doerr, Dirk Sudholt

Evolutionary Computation



Winter 2016, Vol. 24

Special Issue on Combinatorial Optimization Problems

In combinatorial optimization, the goal is to find an optimal solution, according to some objective function, from a discrete search space. These problems arise widely in industry and academia and, unfortunately, many of them are NP-hard and no polynomial time algorithm can guarantee their solution to a certified optimality unless P=NP. Therefore, in the last decades researchers have investigated the use of stochastic search algorithms to find near optimal solutions to these problems. In particular, great research efforts have been devoted to the development and application of metaheuristic algorithms to solve combinatorial optimization problems

This special issue contains six high-quality articles addressing practical applications and theoretical developments of metaheuristic algorithms in the context of combinatorial optimization problems. The articles in this issue have been selected from among 23 submissions after a thorough peer review process. Their contents, outlined in the next paragraphs, reflect the diversity of the application domains and the methods applied to solve the problems.

Existing computational approaches to de novo protein tertiary structure prediction fail to fully scale up to proteins of 100 residues and above. The article “Generating, Maintaining, and Exploiting Diversity in a Memetic Algorithm for Protein Structure Prediction” by Mario Garza-Fabre, Shaun M. Kandathil, Julia Handl, Joshua Knowles, and Simon C. Lovell states that this is mainly due to a lack of exploration of properly diverse protein folds, and to an acute form of deception in the energy function. In the article, solutions to both of these problems are studied through a multistage memetic algorithm incorporating the well-known Rosetta method as a local search routine. The authors state that the obtained results should translate to a noticeable improvement in the performance of protein structure prediction algorithms in blind experiments and, potentially, to a further step towards the more challenging problem of predicting the three-dimensional shape of large proteins. Two articles in the issue deal with automated heuristic design or hyper-heuristics; these approaches aim to increase the level of generality and reduce the role of the human expert when applying heuristic optimization. With the increase of computing power, the use of ensemble methods in machine learning is gaining relevance. The article “A Hyper-Heuristic Ensemble Method for Static Job-Shop Scheduling” by Emma Hart and Kevin Sim proposes a divide-and-conquer strategy where a group of evolved scheduling heuristics is maintained, and each heuristic solves a unique subset of the instance set considered. Heuristics are linear sequences of dispatching rules, where each rule is a tree structure evolved with Genetic Programming. After a training process, the ensemble outperforms both human-made dispatching rules and standard Genetic Programming on the studied benchmarks.

An important but mostly missed promise in hyper-heuristic research is to develop cross-domain approaches, that is, methodologies that work well and with minimum design effort across multiple problem domains. This is achieved by the article “Hybrid Self-Adaptive Evolution Strategies Guided by Neighborhood Structures for Combinatorial Optimization Problems,” where V. N. Coelho et al. address three complex combinatorial optimization problems: the Open-Pit-Mining Operational Planning Problem with dynamic allocation of trucks, the Unrelated Parallel Machine Scheduling Problem with Setup Times, and the calibration of a hybrid fuzzy model for Short-Term Load Forecasting. The proposed method is an Evolution Strategy (ES) that self-adapts its mutation operations which are applied in combination with a Reduced Variable Neighborhood Search (RVNS) strategy. This hybrid approach also fits in the framework of self-adaptive Memetic Algorithms. The adaptive RVNS variant explores specific parts of each available neighborhood, playing with probabilities evolved through the ES evolutionary process. The approach implicitly considers the problem-specific characteristics and the success of a given neighborhood within the search. The self-adaptive ES was able to adapt the mutation operators in such a way that there is a balance between exploration and exploitation throughout the generations of the evolutionary process, producing competitive results on the studied domains.

Nowadays, large amounts of sensible data cross the networks at any time. In order to protect the data from potential intruders, all this information must be ciphered using fast and safe procedures. The article “Evolutionary Algorithms for Boolean Functions in Diverse Domains of Cryptography” by Stjepan Picek, Claude Carlet, Sylvain Guilley, Julian Miller, and Domagoj Jakobovic applies several evolutionary algorithms to find Boolean functions with desired properties to be used in cryptographic algorithms (ciphers). Genetic Algorithms, Genetic Programming, and Cartesian Genetic Programming are used to solve single-objective formulations of the problem, while NSGA-II is used to solve the multiobjective formulations. Two different problems are addressed: one in the context of masking secrets and the other in stream ciphers.

One of the crucial decisions when developing an evolutionary algorithm concerns the choice of a suitable fitness function. The article “A New Cost Function for Evolution of S-Boxes” by Stjepan Picek, Marko Cupic, and Leon Rotim deals with this question in the context of cryptography. More in detail, the authors consider the problem of evolving highly nonlinear S-Boxes that play an important role in many modern cryptographic algorithms. The authors develop a new fitness function for this purpose and present a comprehensive comparison of their new fitness function with current state-of-the-art fitness functions. A experimental study shows that the new fitness function leads not only to better results but also allows the algorithm to obtain these results faster.

Most of the metaheuristic algorithms that are applied to hard combinatorial optimization problems use the objective function as the only source of information of the problem. These are the so-called black-box algorithms. The black-box complexity of a problem class is the number of objective function evaluations that a black-box algorithm requires to solve any problem in the class. Determining the black-box complexity of a problem class allows the researchers to know if it is possible to improve the current black-box algorithms for the class. In “The Unrestricted Black-Box Complexity of Jump Functions,” Maxim Buzdalov, Benjamin Doerr, and Mikhail Kever find upper and lower bounds for the black-box complexity of the class of Jump functions, which model difficult optimization problems for elitist algorithms. As a side effect, a new method for obtaining lower bounds in black-box complexity is presented for the first time.

Guest Editors

Francisco Chicano: University of Malaga, Spain

Christian Blum: University of the Basque Country UPV/EHU, Spain

Gabriela Ochoa: University of Stirling, Scotland

Evolutionary Computation Just Accepted

Posted Online October 11, 2016.

Evolutionary design of classifiers made of droplets containing a nonlinear chemical medium [www]

Konrad Gizynski, Department of Complex Systems, Institute of Physical Chemistry, Polish Academy of Sciences, Kasprzaka: kgizynski@ichf.edu.pl
Gerd Gruenert, Bio Systems Analysis Group, Institute of Computer Science, Friedrich Schiller University Jena: gerd.gruenert@uni-jena.de
Peter Dittrich, Bio Systems Analysis Group, Institute of Computer Science, Friedrich Schiller University Jena: peter.dittrich@uni-jena.de
Jerzy Gorecki, Department of Complex Systems, Institute of Physical Chemistry, Polish Academy of Sciences, Kasprzaka: jgorecki@ichf.edu.pl

Abstract

Unconventional computing devices operating on nonlinear chemical media offer an interesting alternative to standard, semiconductor-based computers. In this work we study in-silico a chemical medium composed of communicating droplets that functions as a database classifier. The droplet network can be “programmed” by an externally provided illumination pattern. The complex relationship between the illumination pattern and the droplet behavior makes manual programming hard. We introduce an evolutionary algorithm that automatically finds the optimal illumination pattern for a given classification problem. Notably, our approach does not require us to prespecify the signals that represent the output classes of the classification problem, which is achieved by using a fitness function that measures the mutual information between chemical oscillation patterns and desired output classes. We illustrate the feasibility of our approach in computer simulations by evolving droplet classifiers for three machine learning datasets. We demonstrate that the same medium composed of 25 droplets located on a square lattice can be successfully used for different classification tasks by applying different illumination patterns as its externally supplied program.

About this 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, such as an employment vacancy? 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

Notice to Contributing Authors to SIG Newsletters

By submitting your article for distribution in the Special Interest Group publication, you hereby grant to ACM the following non-exclusive, perpetual, worldwide rights:

- to publish in print on condition of acceptance by the editor
- to digitize and post your article in the electronic version of this publication
- to include the article in the ACM Digital Library
- to allow users to copy and distribute the article for noncommercial, educational or research purposes

However, as a contributing author, you retain copyright to your article and ACM will make every effort to refer requests for commercial use directly to you.