

CI/CC and Evolutionary Computation

Thomas Weise

Nature Inspired Computation & Applications Laboratory, University of Science and Technology of China

I. INTRODUCTION

Evolutionary Computation (EC, [1]) comprises all Monte Carlo metaheuristics which iteratively refine sets (populations) of multiple candidate solutions. Most EC approaches are either Swarm Intelligence (SI) methods or Evolutionary Algorithms (EAs). SI is inspired by fact that natural systems of many independent, simple agents (such as ants or birds) are often able to find pieces of food or shortest-distance routes very efficiently. EAs, on the other hand, copy the behavior of natural evolution and treat candidate solutions as individuals which compete and reproduce in a virtual environment defined by the user-provided objective function(s). Generation after generation, these individuals adapt to the environment and thus, tend to become suitable solutions for the problem at hand.

II. PAST

The roots of EC go back to the mid-1950s, where the biologist Barricelli [2] began to apply computer-aided simulations in order to gain more insight into the natural evolution. Bremermann [3] and Bledsoe [4] were the first ones to use evolutionary approaches for solving optimization problems. In the early 1980s Genetic Programming emerged as the youngest member of the EA family [5]. The most common SI methods followed in the 1990s [6, 7].

III. PRESENT

Evolutionary Computation now exists for almost 50 years. When taking a look on the current situation of this area, I get the impression that **(1)** countless algorithm variants and analyses have been published and EC became widely accepted *in the research community*. **(2)** Most of the evidence of the efficiency of EAs is based on experiments and empirical studies. Due to the many configuration parameters of EAs and the wide range of existing optimization problems, it is very hard to define meaningful boundaries for performance or required runtime. **(3)** A tendency towards hybridizing optimization techniques can be observed, resulting from this lack of knowledge about which algorithm is “good” for which problem. This trend began in the 1970s [8], lead to the development of Memetic Algorithms [9], and now culminates in the emergence of portfolio methods [10], which choose the best methods from an algorithm portfolio *during* the actual process of solving a given problem. **(4)** Despite the available evidence for the high utility of EAs, practitioners who solve real-world optimization problems

appear to often prefer traditional, exact methods. Large-scale problems, which these approaches cannot handle anymore due to their computational complexity, are often approached manually instead of using metaheuristics which could have provided much better solutions in shorter time [11]. **(5)** The communication between researchers working on metaheuristic optimization and those working on traditional, exact methods is low, both communities appear to be separated.

IV. FUTURE

My humble opinion about the future development in the EC area is that **(1)** in the next ten to twenty years, metaheuristic optimization should undergo a slow *transition from a research area to a service*. Virtually every decision or design task in engineering and business is an optimization problem. Yet currently, only the fewest of them are recognized as such and even fewer are actually solved using a suitable technique. More *joint projects* between research and economy targeting real-world applications are necessary to improve the awareness and trust of practitioners in EC. **(2)** EA research should thus focus on tasks which are interesting for practitioners, such as large-scale real-world problems [11], in order to become more attractive for them. **(3)** Up to date, in my opinion, there exists no framework for analyzing EAs theoretically which provides results that are actually useful in practice. The development of a robust and simple analysis approach would be highly desirable since it would further increase the acceptance of EC. **(4)** A closer cooperation between the EC community and traditional operations researchers should be pursued, since an exchange of ideas would be beneficial for both sides.

REFERENCES

- [1] T. Weise, *Global Optimization Algorithms – Theory and Application*. it-weise.de (self-published): Germany, 2009. [Online]. Available: <http://www.it-weise.de/>
- [2] N. A. Barricelli, “Esempi Numerici di Processi di Evoluzione,” *Methodos*, vol. 6, no. 21–22, pp. 45–68, 1954.
- [3] H. J. Bremermann, “Optimization Through Evolution and Recombination,” in *Self-Organizing Systems (Proceedings of the conference sponsored by the Information Systems Branch of the Office of Naval Research and the Armour Research*

- Foundation of the Illinois Institute of Technology.*), M. C. Yovits, G. T. Jacobi, and G. D. Goldstein, Eds. Spartan Books: Washington, DC, USA, 1962, pp. 93–103. [Online]. Available: <http://holtz.org/Library/Natural%20Science/Physics/>
- [4] W. W. W. Bledsoe, “Lethally Dependent Genes Using Instant Selection,” Panoramic Research, Inc.: Palo Alto, CA, USA, Tech. Rep. PRI 1, 1961.
- [5] S. F. Smith, “A Learning System based on Genetic Adaptive Algorithms,” Ph.D. dissertation, University of Pittsburgh: Pittsburgh, PA, USA, 1980.
- [6] M. Dorigo, V. Maniezzo, and A. Coloni, “The Ant System: Optimization by a Colony of Cooperating Agents,” *IEEE Transactions on Systems, Man, and Cybernetics – Part B: Cybernetics*, vol. 26, no. 1, pp. 29–41, 1996. [Online]. Available: <ftp://iridia.ulb.ac.be/pub/mdorigo/journals/IJ.10-SMC96.pdf>
- [7] R. C. Eberhart and J. Kennedy, “A New Optimizer Using Particle Swarm Theory,” in *Proceedings of the Sixth International Symposium on Micro Machine and Human Science (MHS’95)*. IEEE Computer Society: Piscataway, NJ, USA, 1995, pp. 39–43. [Online]. Available: <http://webmining.spd.louisville.edu/Websites/COMB-OPT/FINAL-PAPERS/SwarmsPaper.pdf>
- [8] J. Bosworth, N. Foo, and B. P. Zeigler, “Comparison of Genetic Algorithms with Conjugate Gradient Methods,” University of Michigan: Ann Arbor, MI, USA, Tech. Rep. 00312-1-T, 1972, other Identifiers: UMR0554. [Online]. Available: <http://hdl.handle.net/2027.42/3761>
- [9] P. Moscato, “On Evolution, Search, Optimization, Genetic Algorithms and Martial Arts: Towards Memetic Algorithms,” Caltech Concurrent Computation Program, California Institute of Technology (Caltech): Pasadena, CA, USA, Tech. Rep. C3P 826, 1989. [Online]. Available: <http://www.densis.fee.unicamp.br/moscato/papers/bigone.ps>
- [10] F. Peng, K. Tang, G. Chen, and X. Yao, “Population-based Algorithm Portfolios for Numerical Optimization,” *IEEE Transactions on Evolutionary Computation (IEEE-EC)*, 2010.
- [11] T. Weise, A. Podlich, K. Reinhard, C. Gorltdt, and K. Geihs, “Evolutionary Freight Transportation Planning,” in *Applications of Evolutionary Computing – Proceedings of EvoWorkshops 2009: EvoCOMNET, EvoENVIRONMENT, EvoFIN, EvoGAMES, EvoHOT, EvoIASP, EvoINTERACTION, EvoMUSART, EvoNUM, EvoSTOC, EvoTRANSLOG (EvoWorkshops’09)*, ser. Theoretical Computer Science and General Issues (SL 1), Lecture Notes in Computer Science (LNCS), M. Giacobini, P. Machado, A. Brabazon, J. McCormack, S. Cagnoni, M. O’Neill, G. A. Di Caro, F. Neri, A. Ekárt, M. Preuß, A. I. Esparcia-Alcázar, F. Rothlauf, M. Farooq, E. Tarantino, A. Fink, and S. Yang, Eds., vol. 5484/2009. Springer-Verlag GmbH: Berlin, Germany, 2009, pp. 768–777, nominated for best paper award. [Online]. Available: <http://www.it-weise.de/documents/files/WPRGG2009EFTP.pdf>

```
@inproceedings{W2010CCAEC,  
  title      = {CI/CC and Evolutionary Computation},  
  author     = {Thomas Weise},  
  booktitle  = {Proceedings of the 9th IEEE International Conference on  
               Cognitive Informatics (ICCI 2010)},  
  month      = jul # {~7--9,},  
  year       = {2010},  
  location   = {Tsinghua University, Beijing, China},  
  publisher  = {IEEE Computer Society Press, Los Alamitos, CA, USA},  
  isbn       = {978-1-4244-8040-1},  
}
```

Preview

This document is a preview version
and not necessarily identical with
the original.

<http://www.it-weise.de/>