

Akhtar, Junaid; Koshul, Basit Bilal; Awais, Mian Muhammad

A framework for evolutionary algorithms based on Charles Sanders Peirce's evolutionary semiotics. (English) Zbl 1284.68522
Inf. Sci. 236, 93-108 (2013).

Summary: One of the objectives of evolutionary computation (EC) has been to understand the processes of natural evolution and then model them algorithmically. Hans-Paul Schwefel, in his 1997 paper on the future challenges for EC argues that the more an algorithm models natural evolution at work in the universe, the better it will perform (even in terms of function optimization). There is enough data to suggest that slight differences in the understanding of the natural evolution can cause the associated evolutionary algorithms (EA) to change characteristically. The present paper tests Schwefel's hypothesis against Charles Sanders Peirce's theory which places semiotics, the theory of signs, at the heart of universal evolution. This course is followed because of three primary reasons. Firstly, Peirce has not been seriously tested in EC, although there have been EA based on other theories and sub-theories. Secondly, Peirce's universal theory, by not being restricted to biological evolution alone, qualifies for Schwefel's hypothesis, perhaps more than most other theories that have already been modeled algorithmically. But most importantly because, in experimental terms, it warrants an original claim that Peirce's insights are useful in improving the existing EA in computer science, as Peircean EA can potentially solve some of the major problems in this area such as the loss of diversity, stagnation, or premature convergence. This paper provides a novel framework and consequently a simple algorithm based on Peirce's theory of evolution, and tests it extensively against a benchmark set of mathematical problems of varying dimensions and complexity. Comparative results with classical and advanced EA form another significant part of the paper, and help in strengthening the viability of Schwefel-Peirce hypothesis for EC.

MSC:

- 68T20** Problem solving in the context of artificial intelligence (heuristics, search strategies, etc.) Cited in 1 Document
- 68T05** Learning and adaptive systems in artificial intelligence

Keywords:

Charles Sanders Peirce; evolutionary algorithms; semiotics; stagnation

Full Text: [DOI](#)

References:

- [1] Angeline, P. J., Evolutionary optimization versus particle swarm optimization: philosophy and performance differences, (Porto, D. W.V. W.; Saravanan, N.; Eiben, A. E., Proc. Evol. Prog., vol. VIII, (1998), Springer-Verlag Berlin, Germany), 601-610
- [2] Bäck, T.; Fogel, D. B.; Michalewicz, Z., Handbook of evolutionary computation, (1997), CRC Press · [Zbl 0883.68001](#)
- [3] K. Balázs, L.T. Kóczy, Genetic and bacterial memetic programming approaches in hierarchical-interpolative fuzzy system construction, in: 2012 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), pp. 1-8.
- [4] Beyer, H. G.; Schwefel, H. P.; Wegener, I., How to analyse evolutionary algorithms, Theoretical Computer Science, 287, 101-130, (2002) · [Zbl 1061.90119](#)
- [5] Caraffini, F.; Neri, F.; Iacca, G.; Mol, A., Parallel memetic structures, Information Sciences, 227, 60-82, (2013)
- [6] Chen, S.; Smith, S., Putting the genetics back into genetic algorithms (reconsidering the role of crossover in hybrid operators), (Wolfgang Banzhaf, C. R., Foundations of Genetic Algorithms, vol. 5, (1999), Morgan Kaufman)
- [7] Chiu, S. L., Fuzzy model identification based on cluster estimation, Journal of Intelligent and Fuzzy Systems, 2, 267-278, (1994)
- [8] Dawkins, R., The selfish gene, (1976), Oxford University Press New York
- [9] Deb, K., Multi-objective optimization using evolutionary algorithms, (2001), John Wiley and Sons · [Zbl 0970.90091](#)
- [10] English, T. M., Evaluation of Evolutionary and Genetic Optimizers: No Free Lunch, Evolutionary Programming, vol. V, (1996), MIT Press
- [11] T. Friedrich, P.S. Oliveto, D. Sudholt, C. Witt, Theoretical analysis of diversity mechanisms for global exploration, in:

Proceedings of the Genetic and Evolutionary Computation Conference (GECCO), 2008, pp. 945-952.

- [12] Fuhrmann, J.; Rurainski, A.; Lenhof, H. P.; Neumann, D., A new Lamarckian genetic algorithm for flexible ligand-receptor docking, *Journal of Computational Chemistry*, 31, 1911-1918, (2010)
- [13] Han, J.; Kamber, M.; Pei, J., *Data mining: concepts and techniques*, (2006), Morgan Kaufman Publishers · [Zbl 1445.68004](#)
- [14] Han, K. H.; Kim, J. H., Quantum-inspired evolutionary algorithms with a new termination criterion, h gate, and two-phase scheme, *IEEE Transactions on Evolutionary Computation*, 8, 156-169, (2004)
- [15] Holland, J. H., *Adaptation in natural and artificial systems*, (1975), University of Michigan Press Ann Arbor, MI, USA
- [16] Hwang, S. F.; He, R. S., A hybrid real-parameter genetic algorithm for function optimization, *Advanced Engineering Informatics*, 20, 7-21, (2006)
- [17] Jaimes, A. L.; Coello, C. A.C., Applications of parallel platforms and models in evolutionary multi-objective optimization, (Lewis, A.; Mostaghim, S.; Randall, M., *Biologically-Inspired Optimisation Methods*, Studies in Computational Intelligence, vol. 210, (2009), Springer Berlin, Heidelberg), 23-49
- [18] Koziel, S.; Michalewicz, Z., Evolutionary algorithms, homomorphous mappings, and constrained parameter optimization, *IEEE Transactions on Evolutionary Computation*, 7, (1999)
- [19] Leung, Y. W.; Wang, Y. P., An orthogonal genetic algorithm with quantization for global numerical optimization, *IEEE Transactions on Evolutionary Computation*, 5, 41-53, (2001)
- [20] Mitchell, M.; Taylor, C. E., Evolutionary computation: an overview, *Annual Review of Ecology and Systematics*, 30, 593-616, (1999)
- [21] Monod, J., *Chance and necessity: an essay on the natural philosophy of modern biology*, (1971), Alfred A. Knopf New York
- [22] P. Moscato, *On Evolution, Search, Optimization, Genetic Algorithms and Martial Arts: Towards Memetic Algorithms*, Technical Report C3P Report 826, California Institute of Technology, 1989.
- [23] Nawa, N. E.; Furuhashi, T., A study on the effect of transfer of genes for the bacterial evolutionary algorithm, (Jain, L. C.; Jain, R. K., *KES*, vol. 3, (1998), IEEE), 585-590
- [24] Ochs, P. W., Charles sanders peirce, (Griffin, D. R.; Cobb, J. B.; Ford, M. P.; Gunter, P. A.Y.; Ochs, P. W., *Founders of Constructive Postmodern Philosophy*, (1993), State University of New York Press), 68-85
- [25] Peirce, C. S., *The Collected Papers of Charles Sanders Peirce*, vol. I-VIII, (1931), Harvard University Press Cambridge, MA, pp. 1931-1958
- [26] Salomon, R., Reevaluating genetic algorithm performance under coordinate rotation of benchmark functions - a survey of some theoretical and practical aspects of genetic algorithms, *BioSystems*, 39, 263-278, (1995)
- [27] Sareni, B.; Krahenbuhl, L., Fitness sharing and niching methods revisited, *IEEE Transactions on Evolutionary Computation*, 2, 97-106, (1998)
- [28] Segura, C.; Segredo, E.; León, C., Parallel island-based multiobjectivised memetic algorithms for a 2d packing problem, (Proceedings of the 13th annual conference on Genetic and evolutionary computation, GECCO '11, (2011), ACM New York, NY, USA), 1611-1618
- [29] Sheriff, J., *Charles peirce's guess at the riddle: grounds for human significance*, (1994), Indiana University Press
- [30] Skolicki, Z., An analysis of island models in evolutionary computation, (Proceedings of the 2005 Workshops on Genetic and Evolutionary Computation, GECCO '05, (2005), ACM New York, NY, USA), 386-389
- [31] H. Spencer, *First Principles*, 2nd ed., Williams and Norgate, London, 1867 (part 2, chapter 18).
- [32] Srinivasa, K. G.; Venugopal, K. R.; Patnaik, L. M., A self-adaptive migration model genetic algorithm for data mining applications, *Information Sciences*, 177, 4295-4313, (2007) · [Zbl 1119.68389](#)
- [33] Whitley, D., A genetic algorithm tutorial, *Statistics and Computing*, 4, 65-85, (1994)
- [34] D.H. Wolpert, W.G. Macready, No Free Lunch Theorems for Search, Technical Report SFI-TR-02-010, Santa Fe Institute, 1995.
- [35] Wolpert, D. H.; Macready, W. G., Coevolutionary free lunches, *IEEE Transactions on Evolutionary Computation*, 9, 721-735, (2005)
- [36] Yao, X.; Liu, Y., Fast evolution strategies, (Angeline, J. M.P. J.; Reynolds, R.; Eberhart, R., *Evolutionary Programming*, vol. VI, (1997), Springer-Verlag Berlin, Germany), 151-161
- [37] Yuan, Q.; Qian, F.; Du, W., A hybrid genetic algorithm with the Baldwin effect, *Information Sciences*, 180, 640-652, (2010) · [Zbl 1187.68570](#)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.