(Over-)Realism in evolutionary computation: Commentary on “On the Mapping of Genotype to Phenotype in Evolutionary Algorithms” by Peter A. Whigham, Grant Dick, and James

(Over-)Realism in Evolutionary Computation

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P2P Commentary

It is a truism that natural processes have been great sources of inspiration for computer scientists. To name a few, McCulloch and Pitts' pioneering model of artificial neural networks (ANN) dates back to the early 1940s [1]; the similarities between natural evolution and learning were pointed out by Turing in 1950 [2], and the whole field of evolutionary computation (EC) is considered by some scholars a direct result of this intuition.

While undeniably useful as starting points, however, inspiring metaphors become less important in mature research fields. For instance, the classical model of neural networks is likely to be biologically incorrect: isolated neurons have recently been shown to possess memory [3], a fact quite inconsistent with the model used in ANNs. Significantly, when last year Vanhoucke introduced Deep Learning in an open, online course sponsored by Google [4], he did not even mention neurons nor axions. Yet, despite the probable lack of a reliable biological basis, ANNs are experiencing a glorious moment, and are widely regarded as the state of the art for many practical applications.

EC originates from the theory of evolution, but its biological foundations are questionable, if not widely inaccurate. A true environment is missing, and it is usually replaced by its oversimplified effect calculated through the fitness function. In such a situation, the relationship between genotype and phenotype, and fitness, is rather unclear; and Grammatical evolution complicates the situation, creating an intermediate representation [5]. Darwin's *principle of divergence* has no correspondence in EC. Genetic operators, selective pressure, mutation rates, and all other parameters are not tweaked evaluating their biological plausibility. And, above all, as also Whigham, Dick, and Maclaurin recall in their paper, evolution is not an optimization process [6, 7].

Evolutionary algorithms (EAs) can be analyzed as mere optimization algorithms performing a stochastic sampling of vast search spaces, followed by random mutation, and recombination that allow to escape local optima. While the originating metaphor is important, what ultimately matters to

practitioners is the algorithm's behavior and performance, not how close it is to a natural phenomenon.

Several techniques used by practitioners for solving industrial problems are barefacedly different from biological processes. For instance, memetic algorithms (MAs) [8] combine the exploitative ability of local search and the exploration power of EAs to obtain the best of the two worlds. Although MAs allegedly take inspiration from the field of *memetics*, they are de facto a mix of two effective optimization techniques, with the objective to create an even more powerful method. MAs obtained several important successes in real-world applications, but, when it comes to the metaphor: Are they mimicking cultural information transfer? Are they performing something similar to Lamarckian evolution theory? These questions might not be relevant: the technique works on difficult problems, and this is its ultimate goal.

In their paper, Whigham, Dick, and Maclaurin discuss the philosophical foundations of GE, identifying properties of the algorithm that are in direct conflict with what is considered to be effective for an evolutionary search. However, we are incline to think that GE cannot benefit from real-world analogies any more. Sterenly's opinions are still extremely interesting when discussing a comprehensive view of evolution, along with the opinions of other scholars who criticized Dawkins' gene-centric approach [9] and his extended phenotypes [10], but they might not be useful to further improve well established EAs.

The recent rise of networking projects such as the European COST Action *Improving Applicability of Nature-Inspired Optimisation by Joining Theory and Practice* (ImAppNIO)[1] shows the need, inside the EC community, to bridge the gap between theoretical analysis of the algorithms and what is used in practice. Sorensen's witty critique on the abuse of metaphors in meta-heuristics [11] could be used as an Occam's razor: biological analogies should be taken into consideration only whether they help bringing significant advantages.

References

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