Bio-Inspired Technique to Produce Strong Competitors for Studies in Artificial-life and Evolutionary Robotics

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In both Artificial-Life (A-Life) studies and in Evolutionary Robotics (ER) the use of bio-inspired evolutionary computation methods is wide. The majority of such studies either use knowledge-base aggregate fitness, or some game definition, to drive the selection. Often the bio-inspired evolution suffers from the bootstrap problem, in which randomly initialized populations have no detectable level of fitness and thus cannot be evolved [1], [2]. From an Artificial–Life (A-Life) viewpoint one may consider the bootstrap problem as trying to evolve high-level creatures from very low level, without considering the evolution of intermediate creatures. Observing nature, it is evident that it contains not just a diversity of creatures, but also diversity of niches and varying conditions over generations. Our approach to overcome the bootstrap problem is based on these observations. In particular we use diversification of solutions and objectives to overcome the bootstrap problem.

Our proposed approach to deal with the bootstrap problem is associated with two existing methods: (a) one that initially relies on a bootstrapping component and later gives way to aggregate selection [3], and (b) one that uses Multi Objective Optimization (MOO) for incremental evolution, in a bio-inspired manner [4]. We suggest a novel method building upon these concepts. First, it exploits MOO to evolve a population of controllers which exhibit several useful, non-task specific, behaviors (explore environment, avoid obstacles, etc.). Secondly, it applies aggregate selection using the previously obtained population as the seed population. This reduces considerably the probability of the population from being sub-minimally competent. As MOO supports diverse search, the overall proposed method remains non-tailored in nature, and thus should scale better to complex problems.

To demonstrate the proposed method, this work employs a competitive coevolution task, namely a soccer game [5], for which aggregate selection is a natural choice. In [5], two simulated Khepera robots compete to score more goals than each other. In **Fig. 1.** the robots are depicted as pacman-like symbols chasing the light colored circle (ball). Apart from proposing and analyzing a novel method for dealing with the bootstrap problem in ER, we expand a recently suggested procedure (equal-effort comparison), and utilize a unique one (end-game comparison), for comparing co-evolutionary methods. In addition, we introduce a slightly modified version of the well established NSGA-II algorithm that makes it suitable for use in co-evolution.

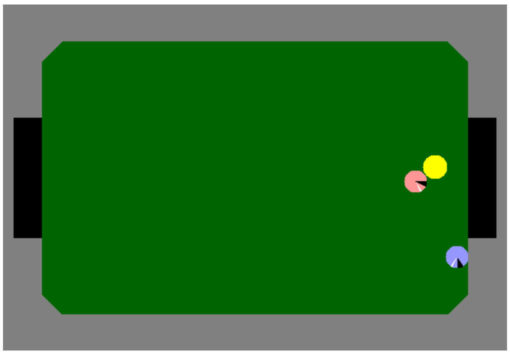

Fig. 1. A snapshot of the domain (as obtained using the website provided in [5]).

An equal-effort comparison is carried out to compare the two-phase method with the conventional co-evolutionary method from [5]. The results for a 300 generations long run are presented in **Fig. 2**. The results indicate that the two-phase method is better in bootstrapping the evolutionary process. However, from the erosion in the advantage of the two-phase method we conclude that, at least in our simulation study, it did not succeed in expressing unique behaviors unreachable by conventional means after enough generations. It is conceivable though that in more complex domains its positive effect will last longer and even persist.

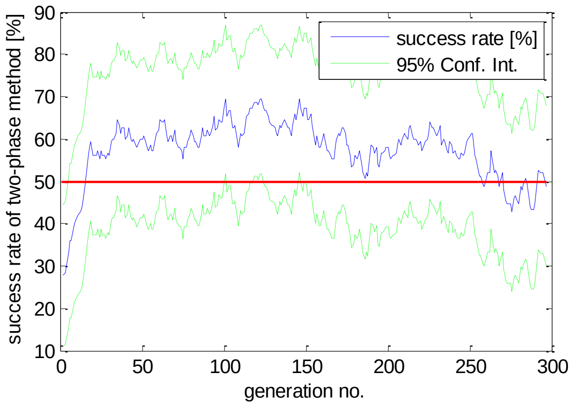

Fig. 2. Equal-effort comparison results

References:

[1] A. L. Nelson, G. J. Barlow and L. Doitsidis, "Fitness functions in evolutionary robotics: A survey and analysis," *Robotics and Autonomous Systems*, vol. 57, pp. 345-370, 2009.

[2] J. B. Mouret and S. Doncieux, "Overcoming the bootstrap problem in evolutionary robotics using behavioral diversity," in *Evolutionary Computation, 2009. CEC'09. IEEE Congress on*, 2009, pp. 1161-1168.

[3] A. L. Nelson and E. Grant, "Using direct competition to select for competent controllers in evolutionary robotics," *Robotics and Autonomous Systems*, vol. 54, pp. 840-857, 2006.

[4] J. B. Mouret and S. Doncieux, "Incremental evolution of animats' behaviors as a multi-objective optimization," *From Animals to Animats 10*, pp. 210-219, 2008.

[5] E. Hallundbæk Óstergaard and H. Hautop Lund, "Co-evolving complex robot behavior," *Evolvable Systems: From Biology to Hardware*, pp. 308-319, 2003.