Elements of Embodied Evolutionary Robotics

Nicolas Bredeche*
[1]Sorbonne Universités, UPMC
Univ Paris 06, UMR 7222,
ISIR, F-75005 Paris, France
[2]CNRS, UMR 7222, ISIR,
F-75005, Paris, France
nicolas.bredeche@upmc.fr

Evert Haasdijk
VU University Amsterdam
Amsterdam, The Netherlands
e.haasdijk@vu.nl

Abraham Prieto
Integrated Group for
Engineering Research
Universidade da Coruña,
Spain
abprieto@udc.es

ABSTRACT

This workshop presentation describes the general concepts behind embodied evolution, and intends to provide an up-to-date view of lessons learned and current open issues.

Categories and Subject Descriptors

I.2 [**Artificial Intelligence**]: Robotics

1. INTRODUCTION

This workshop presentation will discuss evolutionary robotics research where evolution takes place in a population of robots where their controllers evolve. Such a setting implies continuous adaptation of controllers: evolution acts as a persistent force that learns control at population level with the robots that make up the population performing parallel evaluations of candidate controllers even as they use them to perform their tasks (cf. [1, 4, 3] for recent works). This contrasts with most evolutionary robotics research where evolution is employed in the classical sequential centralised optimisation paradigm: the 'robotics' part consists of a series of robotic trials (simulated or not) in an evolution-based search for good robot controllers [2]. Embodied evolution, on the other hand, makes it possible to deploy robots in situations that cannot be accurately modelled a priori, or are expected to change over time.

The term "embodied evolution" was coined in [5]; we elaborate the definition of embodied evolution as evolutionary robotic systems that are:

Parallel Whether they collaborate in their tasks or not, the population consists of multiple robots that perform their actions and evolve in the same scenario, during the same period, and that frequently interact with each other to adapt their controllers together.

Decentralised There is no central authority that selects parents to produce offspring or individuals to be replaced. Instead, robots assess their performance and exchange and select genetic material autonomously using only locally available information;

On-line Robot controllers change on the fly, as the robots go about their proper actions: evolution occurs during the operational lifetime of the robots, continuing after the robots have been deployed.

Because evolution is conducted in a distributed fashion, without any central authority orchestrating the process, embodied evolution requires an additional evolutionary operator in addition to the classic operators (selection, replacement and variation): the **mating** operator. It describes an action where two (or more) robots decide to exchange genetic material, whether this material will or will not be used for generating new offspring. When and how this happens depends both on pre-defined heuristics and the evolved behaviors, as the latter plays a significant role on the encounter between robots.

*__All authors have contributed equally__. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640891.

GECCO'15 Companion, July 11 - 15, 2015, Madrid, Spain

ISBN 978-1-4503-3488-4/15/07…$15.00
DOI: http://dx.doi.org/10.1145/2739482.2768493

2. REFERENCES

[1] N. Bredeche, J.-M. Montanier, W. Liu, and A. F. T. Winfield. Environment-driven Distributed Evolutionary Adaptation in a Population of Autonomous Robotic Agents. *Mathematical and Computer Modelling of Dynamical Systems*, 18(1):101–129, 2012.

[2] S. Doncieux, N. Bredeche, J.-B. Mouret, and A. Eiben. Evolutionary Robotics: What, Why, and Where to. *Frontiers in Robotics and AI*, 2(March):1–18, 2015.

[3] E. Haasdijk, N. Bredeche, and a. E. Eiben. Combining environment-driven adaptation and task-driven optimisation in evolutionary robotics. *PloS one*, 9(6):e98466, Jan. 2014.

[4] P. Trueba, a. Prieto, F. Bellas, P. Caamaño, and R. Duro. Specialization analysis of embodied evolution for robotic collective tasks. *Robotics and Autonomous Systems*, 61(7):682–693, July 2013.

[5] R. A. Watson, S. G. Ficici, and J. B. Pollack. Embodied Evolution: Distributing an evolutionary algorithm in a population of robots. *Robotics and Autonomous Systems*, 39(1):1–18, Apr. 2002.