Roborobo! a Fast Robot Simulator for Swarm and Collective Robotics

Nicolas Bredeche, Jean-Marc Montanier, Berend Weel, Evert Haasdijk

Roborobo! a Fast Robot Simulator for Swarm and Collective Robotics

Nicolas Bredeche
UPMC, CNRS
Paris, France
nicolas.bredeche@isir.upmc.fr

Jean-Marc Montanier
NTNU
Trondheim, Norway
montanier.jeanmarc@gmail.com

Berend Weel
Vrije Universiteit Amsterdam
The Netherlands
b.weel@vu.nl

Evert Haasdijk
Vrije Universiteit Amsterdam
The Netherlands
e.haasdijk@vu.nl

ABSTRACT

Roborobo! is a multi-platform, highly portable, robot simulator for large-scale collective robotics experiments. Roborobo! is coded in C++, and follows the KISS guideline ("Keep it simple"). Therefore, its external dependency is solely limited to the widely available SDL library for fast 2D Graphics. Roborobo! is based on a Khepera/ePuck model. It is targeted for fast single and multi-robots simulation, and has already been used in more than a dozen published research mainly concerned with evolutionary swarm robotics, including environment-driven self-adaptation and distributed evolutionary optimization, as well as online onboard embodied evolution and embodied morphogenesis.

Keywords

robot simulator, evolutionary robotics, swarm robotics, collective adaptive systems, C++, SDL graphics library

1. INTRODUCTION

This paper introduces Roborobo!, a light-weight multi-platform simulator for extensive robotics experiment, based on basic robotic hardware setup similar to the famous ePuck [5] or Khepera [13] robotic platforms. Roborobo! is mostly intended at, but not limited to, researchers and practictionners interested in collective adaptive systems and evolutionary robotics, with a particular emphasis on embodied evolution (ie. online evolution) and swarm robotics (> 100 robots, as illustrated in Figure 1). The underlying idea is to provide a versatile framework for easy development of new ideas and very fast and robust implementation for extensive experiments. Roborobo! is available under the new BSD Licence [18] at `https://code.google.com/p/Roborobo/`.

With respect to other robotic simulators, Roborobo! takes an intermediate approach to model a robotic setup in order to combine (pseudo-)realistic modelling with fast-paced simulation. As such, it stands inbetween realistic, but slow, robotic simulation framework (such as Player/Stage [8], Webots [26], V-Rep [25], Gazebo [7] or Microsoft Robotic Developper Studio [17]), and unrealistic, but easy to use, agent-based simulation tools such as Netlogo [24] and MASON [12]. It also differs from easy-access and fast robotic agent simulators such as Breve [11] and Simbad [9], by focusing solely on swarm and aggregate of robotic units, focusing on large-scale population of robots[1] in 2-dimensional worlds rather than more complex 3-dimensional models.

Roborobo! is written in $C++$ with the multi-platform SDL graphics library [22] as unique dependency, enabling easy and fast deployment. It has been tested on a large set of platforms (PC, Mac, OpenPandora [20], Raspberry Pi [21]) and operating systems (Linux, MacOS X, MS Windows). It has also been deployed on large clusters, such as the french Grid5000 [4] national clusters. Roborobo! has been initiated in 2009 and is used on a daily basis in several universities for both research and education, including Universite Paris-Sud and Universite Pierre et Marie Curie (France), Vrije Universiteit Amsterdam (NL), and NTNU (Norway).

Roborobo! was originaly developped by Nicolas Bredeche in 2009 in the context of the european Symbrion Integrated Project [23], and has been continuously extended since then. It has been extensively used in various contexts, mostly concerned with evolutionary robotics and swarm robotics, including embodied evolution [10, 6], environment-driven evolutionary adaptation [14, 1, 16, 15, 3, 2, 19] and self-assembly [28, 27].

Acknowledgments

The authors wish to thank all people who contributed to this project, including Leo Cazenille. This work was made possible by the European Union FET Proactive Initiative: Pervasive Adaptation funding the Symbrion project under grant agreement 216342. Roborobo! was extensively tested in a cluster environment using the Grid'5000 experimental testbed, being developed under the INRIA ALADDIN development action with support from CNRS, RENATER and several Universities as well as other funding bodies (see https://www.grid5000.fr).

2. REFERENCES

[1] N. Bredeche and J.-M. Montanier. Environment-driven Embodied Evolution in a Population of Autonomous Agents. In *The 11th International Conference on Parallel Problem Solving From Nature (PPSN 2010)*, pages 290–299, 2010.

[1]e.g. Roborobo! is able to run with up to 6000 robots on a 4GB laptop computer.

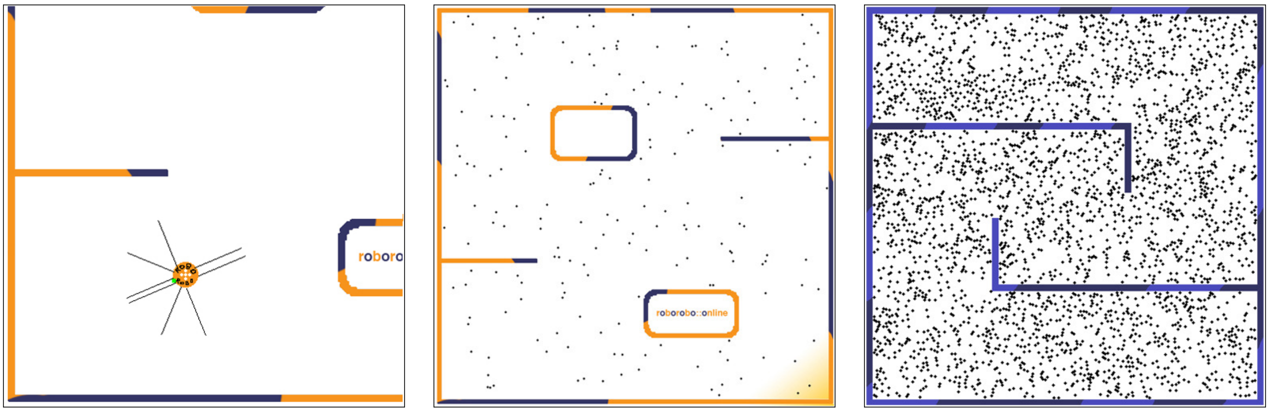

Figure 1: Classic examples with 1 virtual (e-puck) agent, incl. IR sensor rays (left) ; 100 virtual agents (center) ; 5000 virtual agents (right).

[2] N. Bredeche and J.-M. Montanier. Open-ended evolution with a population of autonomous robots. In *Workshop on Evolution of Physical Systems at ALIFE XIII*, July 2012.

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

[4] F. Cappello, E. Caron, M. Daydé, F. Desprez, Y. Jégou, P. Primet, E. Jeannot, S. Lanteri, J. Leduc, N. Melab, G. Mornet, R. Namyst, B. Quetier, and O. Richard. Grid'5000: a large scale and highly reconfigurable grid experimental testbed. In *Grid Computing, 2005. The 6th IEEE/ACM International Workshop on*, pages 8 pp.+, 2005.

[5] http://www.e-puck.org.

[6] P. García-Sánchez, A. Eiben, E. Haasdijk, B. Weel, and J.-J. Merelo-Guervós. Testing diversity-enhancing migration policies for hybrid on-line evolution of robot controllers. pages 52–62, 2012.

[7] http://gazebosim.org.

[8] B. P. Gerkey, R. T. Vaughan, and A. Howard. The player/stage project: Tools for multi-robot and distributed sensor systems. In *In Proceedings of the 11th International Conference on Advanced Robotics*, pages 317–323, 2003.

[9] L. Hugues and N. Bredeche. Simbad: An autonomous robot simulation package for education and research. In *From Animals to Animats 9, 9th International Conference on Simulation of Adaptive Behavior, Proceedings*, pages 831–842, 2006.

[10] R.-J. Huijsman, E. Haasdijk, and A. E. Eiben. An on-line on-board distributed algorithm for evolutionary robotics. pages 119–131, 2011.

[11] J. Klein. breve: a 3d environment for the simulation of decentralized systems and artificial life. In *Proceedings of the eighth international conference on Artificial life*, ICAL 2003, pages 329–334, Cambridge, MA, USA, 2003. MIT Press.

[12] http://cs.gmu.edu/ eclab/projects/mason.

[13] F. Mondada, E. Franzi, and A. Guignard. The Development of Khepera. In *Experiments with the Mini-Robot Khepera, Proceedings of the First International Khepera Workshop*, HNI-Verlagsschriftenreihe, Heinz Nixdorf Institut, pages 7–14, 1999.

[14] J.-M. Montanier and N. Bredeche. Embedded evolutionary robotics: the (1+1)-restart-online adaptation algorithm. In *IEEE IROS Workshop on Exploring new horizons in Evolutionary Design of Robots (Evoderob09)*, pages 37–43, Oct. 2009.

[15] J.-M. Montanier and N. Bredeche. Emergence of altruism in open-ended evolution in a population of autonomous agents. (poster). In *Proceedings of GECCO 2011*, pages 25–26, July 2011.

[16] J.-M. Montanier and N. Bredeche. Surviving the tragedy of commons: Emergence of altruism in a population of evolving autonomous agents. In *Proceedings of the 11th European Conference on Artificial Life (ECAL'11)*, pages 550–557, Aug. 2011.

[17] http://www.microsoft.com/robotics.

[18] http://opensource.org/licenses/BSD-3-Clause.

[19] N. Noskov, E. Haasdijk, B. Weel, and A. Eiben. Monee: Multi-objective and open-ended evolution. In *Applications of Evolutionary Computation: EvoApplications 2013*. Springer-Verlag, 2013. to be published.

[20] http://www.openpandora.org/.

[21] http://www.raspberrypi.org/.

[22] http://www.libsdl.org/.

[23] http://www.symbrion.eu.

[24] S. Tisue and U. Wilensky. Netlogo: A simple environment for modeling complexity. In *in International Conference on Complex Systems*, pages 16–21, 2004.

[25] http://www.coppeliarobotics.com.

[26] http://www.cyberbotics.com.

[27] B. Weel, E. Haasdijk, and A. Eiben. Body building: Hatching robot organisms. In *Proceedings of the 2013 IEEE Symposium Series on Computational Intelligence*. IEEE, IEEE Press, 2013. to be published.

[28] B. Weel, E. Haasdijk, and A. E. Eiben. The emergence of multi-cellular robot organisms through on-line on-board evolution. In C. Di Chio *et al*, editor, *Applications of Evolutionary Computation*, volume 7248 of *Lecture Notes in Computer Science*, pages 124–134. Springer, 2012.