Autonomous exploration, active learning and human guidance with open-source Poppy humanoid robot platform and Explauto library

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1 Introduction

Our demonstration presents an open-source hardware and software platform which allows non-roboticists researchers to conduct machine learning experiments to benchmark algorithms for autonomous exploration and active learning. In particular, in addition to showing the general properties of the platform such as its modularity and usability, we will demonstrate the online functioning of a particular algorithm which allows efficient learning of multiple forward and inverse models and can leverage information from human guidance. A first aspect of our demonstration is to illustrate the ease of use of the 3D printed low-cost Poppy humanoid robotic platform, that allows non-roboticists to quickly set up and program robotic experiments. A second aspect is to show how the Explauto library allows systematic comparison and evaluation of active learning and exploration algorithms in sensorimotor spaces, through a Python API to select already implemented exploration algorithms. The third idea is to showcase Active Model Babbling, an efficient exploration algorithm dynamically choosing which task/goal space to explore and particular goals to reach, and integrating social guidance from humans in real time to drive exploration towards particular objects or actions.

2 Poppy

Poppy is the first complete open-source 3D printed humanoid platform [Lapeyre et al., 2014]. Robust and accessible, it allows scientists, students, geeks, engineers or artists to explore fastly and easily the fabrication and programming of various robotic morphologies. Both hardware and software are open-source, and a web platform allows interdisciplinary contributions, sharing and collaborations. A Raspberry Pi inside the robot runs a Jupyter notebook allowing users to easily program and control the robot from a computer, tablet or smartphone.

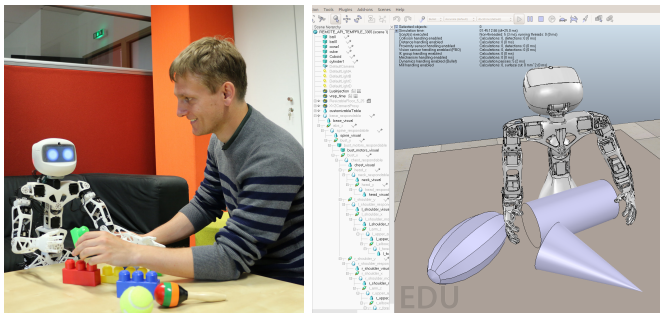

Figure 1: (a) Poppy Humanoid. (b) Poppy Torso in the V-REP simulator.

3 Explauto

Explauto is an open-source Python library providing a unified API to design and compare various exploration strategies driving various sensorimotor learning algorithms in various simulated or robotics systems [Moulin-Frier et al., 2014]. Explauto aims at being collaborative and pedagogic, with a documentation using Jupyter notebooks, providing a platform to roboticists where they can publish, compare and share reproducible algorithmic contributions related to autonomous exploration and learning, as well as a platform for teaching and scientific diffusion (`https://github.com/flowersteam/explauto`).

3.1 Active Model Babbling

A particular exploration strategy available in Explauto is called Active Model Babbling [Forestier and Oudeyer, 2016]. With this strategy, different motor and sensory spaces are given to the robot, e.g. the space of motor parameters of a robotic arm, and sensory spaces representing the movement of each object in the scene, and the robot will learn behavioral primitives to explore and reach new effects in the different sensory spaces. The exploration of one sensory space can give information in the other spaces, and the robot can learn that some objects (e.g. a joystick) can be used as a tool to control other objects (e.g. another robot) in a hierarchical manner. This strategy was shown to be very efficient to explore multiple task/goal spaces based on the monitoring of learning progress in the different spaces. A Jupyter notebook implementing and studying this strategy is available online at this address: `http://nbviewer.jupyter.org/github/sebastien-forestier/ExplorationAlgorithms/blob/master/main.ipynb`.

3.2 Interaction

In the Active Model Babbling exploration strategy, guidance from human peers can be integrated at different levels. When the robot is set up in a compliant mode, human peers can demonstrate robotic movements that the robot stores and can reuse later in its autonomous exploration by experimenting again those movements or variations of the movements as in [Nguyen and Oudeyer, 2012]. Also, users can demonstrate the function of objects or create situations (e.g. use the joystick controling the second robot to grab a ball) that the robot will try to reproduce by exploring new motor primitives. Finally, users can also give a value about the interestingness to explore some task/goal spaces (e.g. moving the blue ball), that will be combined with the intrinsic motivation of the robot and will push it to explore those spaces.

4 Demonstration Setup

The demonstration shows how the Explauto library allows a Poppy Torso to explore its environment and use social guidance to understand the interaction between the different objects in the environment. The robot interacts with several objects including a joystick that controls another robot that can be used as a tool to move other objects. Naive humans can interact with the robot by driving its exploration towards interesting objects, or by demonstrating useful movements of the arm or the joystick.

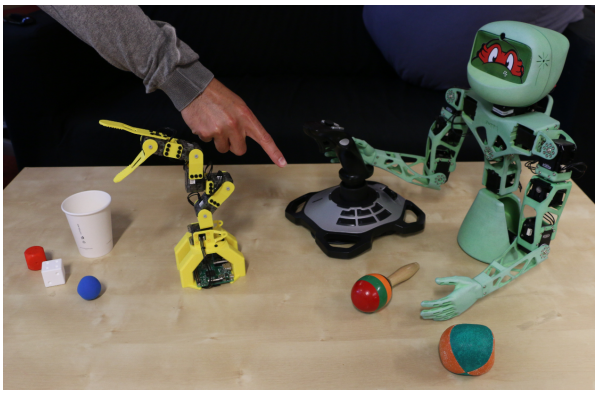

Figure 2: Demonstration setup.

References

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