Explauto: an open-source Python library for active and online sensorimotor learning

Clément Moulin-Frier, Pierre Rouanet, Pierre-Yves Oudeyer
Flowers team, Inria/ENSTA-Paristech
Bordeaux, France
Email: {firstname}.{lastname}@inria.fr

Last year at the ICDL-Epirob conference [1], we presented a probabilistic framework unifying two important families of exploration mechanisms recently shown to be efficient to learn complex non-linear redundant sensorimotor mappings, i.e. the mappings between the motor actions made by a robot and the sensory effects they produce. These two exploration mechanisms are: 1) goal babbling [2], [3] and 2) active learning driven by the maximization of empirically measured learning progress [4], [3]. Both principles can be combined in various ways to achieve efficient exploration strategies –as opposed to random motor babbling, where collected sensorimotor data are generally too sparse to efficiently feed machine learning algorithms. This is especially true when the motor and sensory spaces are highly dimensional, the mapping between them is non-linear and redundant, and there is limited time allowed for learning –the general case of robotic systems. We now provide an open-source Python library, called Explauto , providing a unified API to design and compare various exploration strategies driving various sensorimotor learning algorithms in various simulated or robotics systems. Explauto aims at being collaborative and pedagogic, providing a platform to developmental roboticists where they can publish and compare their algorithmic contributions related to autonomous exploration and learning, as well as a platform for teaching and scientific diffusion. The library is available at this address: **https://github.com/flowersteam/explauto.**

The Explauto architecture is based on three interacting modules: the sensorimotor system (or environment), the sensorimotor model and the interest model.

We call *sensorimotor system* the physical properties of the robot and the environment in which it evolves. Programmatically, the sensory motor system must implement a way to compute the sensory effect corresponding to a given motor action. In the current version of the library, we provide two simulated sensorimotor systems (a multi-joint arm acting on a plan and an under-actuated torque-controlled inverse pendulum) as well as a system allowing the control of real robots based on Dynamixel actuators by providing bindings to the Pypot library[1].

The cognitive architecture of an agent is then composed by a *sensorimotor model*, which iteratively learns internal forward and inverse models from experience, and an *interest model* which actively chooses where to explore in the sensorimotor space. A *sensorimotor model* implements both the iterative learning process from sensorimotor experience and the use of the resulting internal model to perform forward and inverse predictions. Explauto provides several sensorimotor models: simple nearest-neighbor look-up, non-parametric models combining classical regressions and optimization algorithms, online local mixtures of Gaussians, and discrete Lindstone distributions. An *interest model* implements the active exploration process, where sensorimotor experiments are chosen to improve the forward or inverse prediction of the sensorimotor model. It explores in a given *interest space* where a sampling procedure has to be implemented. Explauto provides several sampling procedures: random sampling as well as sampling maximizing the learning progress in forward or inverse predictions.

The library comes with a high level programming interface to compare the built-in, optional or user-defined implementations of sensorimotor systems, sensorimotor models and interest models. It automatically takes advantage of the multi-core processors commonly found in modern personal computers, allowing the parallel execution of multiple experiments. It also contains visualisation tools.

Explauto is distributed under an open-source license (GNU GPL V3) and can be easily extended by suggesting new sensorimotor systems, sensorimotor models and interest models. We encourage anyone to contribute by sending us pull-requests from our Github public repository.

References

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[1] https://github.com/poppy-project/pypot