PERSYVAL-Lab

ROBOTS in HUMAN ENVIRONMENTS

Acquiring Human-Robot Interaction skills with Transfer Learning Techniques

Keywords: Robotics, Machine Leaning, Automated Planning.

Context

Robotics is a reasonably mature technology when robots are restricted to operating with well-known and well-engineered environments, e.g., as in manufacturing robotics, or to performing simple tasks, e.g., vacuum cleaning or lawn mowing. For more diverse tasks and open-ended environments, robotics remains a very active research field. Most of the one million robots deployed today basically, requires hand-coding the environment model and the robot's skills and strategies in a reactive manner. This is a perfectly feasible approach as long as this hand-coding is inexpensive and reliable enough for application at hand. This will be the case if the environment is well structured and stable and if the robot's tasks are restricted in scope and diversity, with only limited human-robot interaction. However, if a robot has to face a diversity of tasks and/or a variety of environment, then this robot has to use more complex approaches based on planning techniques [1] to decide how to act in the environment and based on machine learning techniques [2] to learn new skills.

In spite of this analysis, planning is struggling to be deployed in robotics for various reasons, among which are the restrictive assumptions and expressiveness of classical planning framework. In robotics, task planning should ideally handle time and resource allocation, dynamic environments, uncertainty and partial knowledge, and incremental planning consistently integrated with acting and sensing. The mature planning techniques available today are mostly effective at a high level of task abstraction. Primitive tasks are tasks such as "navigate to", "retrieve" or "pick-up" an object. However, these tasks are far from being primitive sensory–motor functions. Their design is complex and prone to errors. However, planning representation expressiveness allows to model tasks and planning techniques are capable to generate high-level abstraction plans with alternatives to robustly achieve the targeted tasks.

In other hand, machine learning (ML) techniques and particularly transfer-learning techniques [3] are promising approaches to enable robots to learn new skills or transfer behaviours learnt by one robot to another. ML techniques may be applied at several levels: from low-level sensorimotor calibration [4], sensorimotor patterns that trigger primitive tasks [5] to the high-level learning of the organization of these elementary tasks for solving joint objectives [6]. Human learners appear to have inherent ways to transfer knowledge between environmental conditions, tasks and between each other. That is, we recognize and apply relevant knowledge from previous learning experiences when we encounter new environments or new tasks. The more related a new task is to our previous experience, the more easily we can master it. Common machine learning algorithms, in contrast, traditionally address isolated tasks. Transfer learning attempts to change this by developing methods to transfer knowledge learned in one or more source tasks, and to use it in order to improve learning in a related targeted task. Techniques enabling knowledge transfer represent a breakthrough towards making machine learning as efficient as human learning.

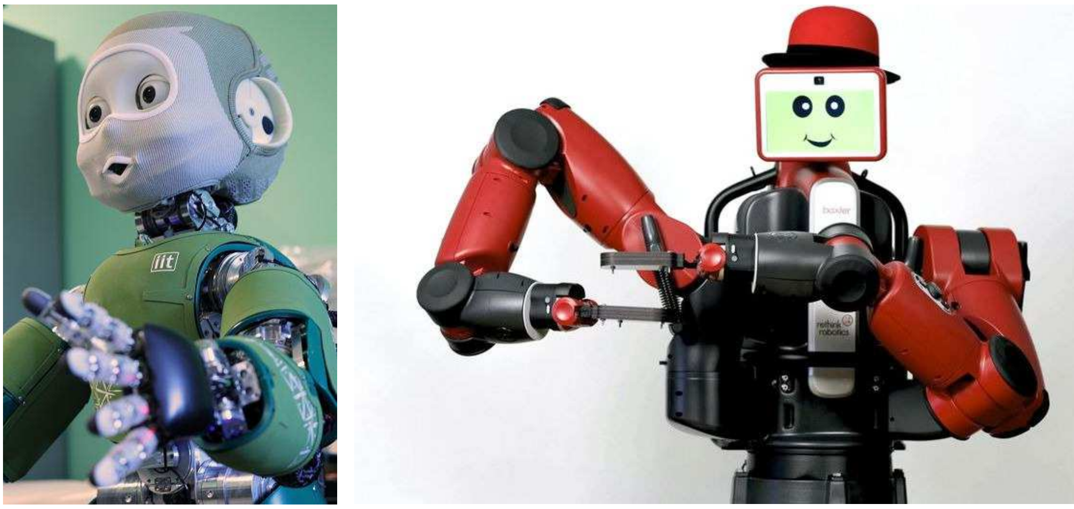

Figure 1 : NINA, the talking iCub2.0 at GIPSA-Lab/CRISSP and Baxter, the dexterous robot at LIG-Lab/MAGMA.

Objectives

In the context of transfer learning techniques, the main objective of the thesis is to learn Human-Robot Interaction task models usable in planning systems embedded in a robot architecture. The learning techniques device will be evaluated in carefully devised situations of Human-Robot Interaction on two available robotics platforms (see Figure 1): I-Cub (GIPSA) and Baxter (LIG). Taking advantage of the availability of these two robots with different sensorimotor capabilities, we will also explore transfer learning techniques between robots.

Contacts

- Damien Pellier, LIG-Lab/MAGMA, damien.pellier@imag.fr
- Gérard BAILLY, GIPSA-Lab/CRISSP, gerard.bailly@gipsa-lab..fr

Application requirements

Interested candidates pursuing a degree in Robotics, Electrical Engineering, Mechanical Engineering, Artificial Intelligence, Computer Vision, Computer Science, or other related fields are invited to apply for admission. Fluency in English is required and knowledge of French is a plus. The candidate should be experienced in object-oriented software development (C++, Java). Any additional Robotics experience is welcome.

References

[1] M. Ghallab, D. Nau and P. Traverso, "Automated Planning", Morgan-Kaufman, 2004.
[2] Antoine Cornuéjols, Laurent Miclet, Yves Kodratoff, *Apprentissage Artificiel : Concepts et algorithmes*, Eyrolles, 2002.
[3] Sinno Jialin Pan; Qiang Yang, (2010) "A Survey on Transfer Learning," IEEE Transactions on Knowledge and Data Engineering, 22(10): 1345-1359.
[4] Hueber T., L. Girin, X. Alameda and G. Bailly (2015) "Speaker-adaptive acoustic-articulatory inversion using cascaded Gaussian mixture regression." Transactions on Audio, Speech and Language Processing, 23(12): 2246-2259.
[5] Şahin, E., Cakmak, M., Doğar, M. R., Uğur, E., & Üçoluk, G. (2007). To afford or not to afford: A new formalization of affordances toward affordance-based robot control. *Adaptive Behavior*, *15*(4), 447-472.
[6] García-Martínez, Ramón, and Daniel Borrajo. "An integrated approach of learning, planning, and execution." Journal of Intelligent and Robotic Systems 29, no. 1 (2000): 47-78.