Developmental Learning of Motor Skills in a Humanoid Robot

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I. Introduction

The future of humanoid robots is to become efficient helpers for humans, both in the execution of everyday tasks and in the accomplishment of tedious and dangerous works. Driven by this vision, researchers have been challenged to design more and more complex robots, that show an increasing number of degrees of freedom and sensors [1], [2]; these robots should be able to cope with the unstructured environment in which humans daily live and act. In particular, it would be desirable that robot behaviors become autonomous (not requiring the supervision of a human expert) and flexible (applicable to different situations and contexts).

However, as robots become more complex, building the analytical models needed for robot control is turning more and more difficult and time-consuming. Moreover, the lack of knowledge of certain hard to measure physical parameters and the existence of highly non-linear physical interactions, makes it infeasible to obtain adequate and accurate models for such kind of systems [3]; as a consequence, resorting to modern machine learning techniques is becoming a more and more popular way to provide these complex robots with the necessary representation capability (see [4] for a recent survey).

In this talk I will present some of the results I obtained during the last five years in providing humanoid robots with the ability to learn motor skills (i.e. internal sensorimotor models) i) autonomously and ii) incrementally during the exploration of the environment. The approach I have been following focuses on some distinctive aspects:

- goal-oriented exploration of the environment (i.e. learning a general model by trying to accomplish specific tasks);
- life-long continuous learning (accounting for both gradual and abrupt modifications in the system);
- developmental framework (the acquisition of a motor skill may allow to gather data to learn a new motor skill);
- bio-inspired (human-inspired) control strategies.

I will discuss why goal-directed exploration is beneficial [5], and how suggestions from biology can help to build better robotic systems. In particular, I will sketch a developmental path in which a robot starts from basic visual perception (i.e. the ability to locate an object of interest inside a 2D image) to finally achieve goal-directed visually-guided locomotion and intelligent whole-body reaching capabilities, including the ability to reach with tools.

Namely, first the robot learns how to the control the neck [6] and eyes to fixate targets in the environment, then it starts learning arm reaching [7] (also using different tools [9]), then it builds incrementally a representation of its own reachable space [8], and finally it exploits this knowledge to perform whole-body reaching and goal-directed walking, that are seen as ways to maximize the reachability of visually detected objects.

I will present results obtained on different humanoid robots (namely, James [10], Kobian [2] and iCub [1]) across the past years.

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