AUTONOMOUS ON-LINE LEARNING OF REACHING BEHAVIOR IN A HUMANOID ROBOT

LORENZO JAMONE, LORENZO NATALE, GIORGIO METTA, GIULIO SANDINI

lorenzo.jamone@iit.it, lorenzo.natale@iit.it, giorgio.metta@iit.it, giulio.sandini@iit.it
Italian Institute of Technology (IIT) - RBCS Department, Genova, ITALY

1. Abstract

Reaching for objects is one of the more studied behaviors, both in humans and in humanoids. This is because it is a fundamental component of many activities of daily living: it is necessary to intercept moving objects, to grasp, manipulate and use them, to interact with people. Humanoid robots which are aimed to help us in our everyday life need to possess this skill, and we want them to learn it autonomously.

The aim of this work is to build a system which enables a humanoid robot to learn how to reach for a visually identified object (in the 3D cartesian space) by the means of a continuous and autonomous on-line learning process. The robotic platform (in Figure 1) is a 22-DOF humanoid torso with moving eyes, neck, arm and hand [2]. The reaching controller consists of two parts, an open-loop controller which brings the hand in the proximity of the target and a closed-loop controller whose aim is to correct hand position errors after the open-loop movement. The robot starts without any a-priori knowledge about the environment and about itself, except for five pre-programmed arm positions which can bring the hand roughly in the visual field, depending on head configuration (something which recalls the ATNR shown by newborns). The open-loop controller uses a head-arm kinematic map, implemented with a Receptive Field Neural Network [3], while the closed-loop controller uses a visual-arm Jacobian map, realized through the combined use of a Receptive Field Neural Network and an incremental least square algorithm [1]. These two maps are learned autonomously by the robot, on-line, during the accomplishment of reaching tasks, that are elicited by visual stimuli (i.e. presence of an object in the visual field, detected by the robot attention system). Differently from previous works, there is no separation between an exploration and an exploitation phase; on the contrary, the robot shows a continuous behavior, always goal-directed, whose performances evolve with time. The robot is always ready to update its knowledge if, for any reason (e.g. changes in its own body structure, sensors, actuators), it is no more able to fulfill the reaching tasks. A change in the required reaching accuracy (i.e. the threshold under which we consider the target as reached) forces the robot to increase the accuracy of its neural structures.

Preliminary experiments (see Figure 2) demonstrate that the learning strategy is efficient as the reaching errors (distance of the hand from the target location in visual coordinates, measured in pixels) decrease with learning.

References

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[3] S. Schaal and C. G. Atkenson. Constructive incremental learning from only local information. *Neural Computation*, 10(8):2047–2084, 1998.

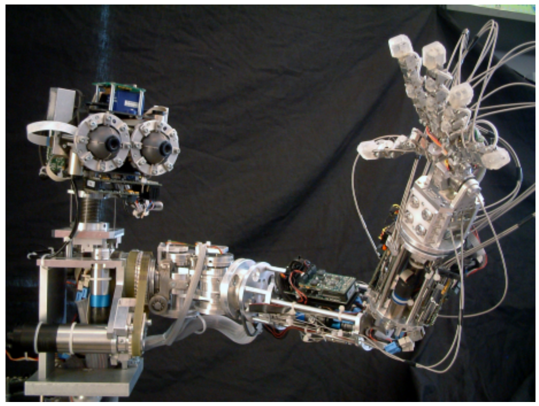

FIGURE 1. The humanoid robot James.

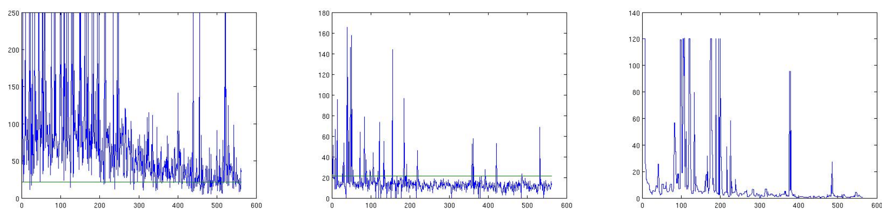

FIGURE 2. Position errors after the ballistic movement (pixels), position errors after the Jacobian-based correction (pixels), time duration of the Jacobian-based correction (seconds). The green straight line in the first two graphs is the reaching threshold. On X-axis: number of reaching trials.