Action Development and Integration in an Humanoid iCub Robot

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Abstract. One major challenge in adaptive/developmental robotics is constituted by the need to identify design principles that allow robots to acquire and display different behavioral skills by consistently and scalably integrating new behaviors into their existing behavioral repertoire. In this paper we briefly present a novel method that can address this objective, the theoretical background behind the proposed methodology, and the preliminary results obtained in a series of experiments in which a humanoid iCub robot develops progressively more complex object manipulation skills through an incremental language mediated training process.

1 Theoretical Background and Proposed Methodology

A first theoretical assumption behind our approach is that behavioral and cognitive processes in embodied agents should be conceived as dynamical processes with a multi-level and multi-scale organization (Nolfi, 2006). This means that behavior (and cognitive skills) are: (i) dynamical processes originating from the continuous interaction between the robot and the physical and social environment, and (ii) display a multi-level and multi-scale organization in which the combination and interaction between lower-level behaviors, lasting for limited time duration, give rise to higher-level behaviors, extending over longer time scale and in which higher-level behaviors later affect lower-level behaviors and the robot/environmental interaction from which they arise. This assumption implies that a behavioral unit does not necessarily correspond to a dedicated control unit or modules of the robot's neural controller. Moreover, it implies that the development of additional and higher-level behavior can occur through the recombination and re-use of pre-existing motor skills even when these skills do not correspond to separated physical entities but rather to processes that ultimately emerge from the robot/environmental interactions.

The second theoretical assumption postulates that social interaction, with particular reference to linguistic mediated social interactions and self-talk (i.e. the possibility to talk to yourself) can promote the development and the integration of multiple action skills (for a related view see Zhang & Weng, 2007; Mirolli & Parisi, 2011).

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2 Model and Experimental Scenario

In line with the assumptions described above we investigated whether a humanoid iCub robot provided with an non-modular neural network controller can: (1) develop a set of elementary actions, such as REACH-OBJECT, REACH-LOCATION, GRASP, OPEN (i.e. reach a colored object placed on a table, a given target location in the robot's peripersonal space, close the fingers around an object, open the fingers) and then (2) develop higher-level integrated actions such as MOVE-OBJECT (i.e. reach a colored object, grasp it, move and then release the object in a target location).

The developmental process has been carried out in two phases. During the first phase, the robot is trained for the ability to produce the required elementary behavior in variable robot/environmental conditions and to respond to the linguistic command (e.g. "reach-object" or "grasp") produced by the caretaker by eliciting the appropriate behavior. During the second phase, the robot is trained for the ability to produce complex integrated behaviors in a linguistic assisted condition (in which the caretaker produces the appropriate sequence of linguistic inputs: "move-object", "reach-object", open, "grasp", "reach-location", and "open") and for the ability to self-talk (i.e. for the ability to self-generate and anticipate the linguistic commands produced by the caretaker).

3 Results and Conclusions

The analysis of an initial set of experiments carried out by using a realistic simulation of the robot and of the physical robot/environmental interaction demonstrated how the robot can successfully acquire the chosen lower-level and higher-level behaviors. At the end of the training process the robot also shows an ability to produce higher level behaviors autonomously through the exploitation of self-talk (i.e. the ability to self-generate sequences of linguistic commands analogous to those provided by the caretaker during training).

More generally the comparison of different training conditions indicate that: (i) the realization of an incremental training process and the scaffolding role provided by the caretaker constitutes a crucial prerequisite for the ability to master the task, and (ii) the availability of linguistic input associated to goal oriented behavior promotes the emergence of behavioral units that can then be re-used and recombined to produce integrated higher-level behaviors.

References

Nolfi, S.: Behaviour as a complex adaptive system: on the role of self-organization in the development of individual and collective behaviour. ComplexUs 2(3-4), 195–203 (2006)

Mirolli, M., Parisi, D.: Towards a Vygotskyan Cognitive Robotics: The Role of Language as a Cognitive Tool. New Ideas in Psychology 9, 298–311 (2011)

Zhang, Y., Weng, J.: Task transfer by a developmental robot. IEEE Transactions on Evolutionary Computation 2(11), 226–248 (2007)