Chapter 65
Developmental Language Learning from Human/Humanoid Robot Social Interactions: An Embodied and Situated Approach

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ABSTRACT

This chapter presents work on developmental machine learning strategies applied to robots for language acquisition. The authors focus on learning by scaffolding and emphasize the role of the human caregiver for robot learning. Indeed, language acquisition does not occur in isolation, neither can it be a robot's "genetic legacy." Rather, they propose that language is best acquired incrementally, in a social context, through human-robot interactions in which humans guide the robot, as if it were a child, through the learning process. The authors briefly discuss psychological models related to this work and describe and discuss computational models that they implemented for robot language acquisition. The authors aim to introduce robots into our society and treat them as us, using child development as a metaphor for robots' developmental language learning.

INTRODUCTION: DEVELOPMENTAL LEARNING

Teaching a multi-sensory artificial intelligence system to learn information concerning the surrounding world is a difficult task, which takes several years for a child, equipped with complex learning mechanisms, to accomplish. Indeed, the human body contains all sorts of multi-sensory elements very well adapted to the environment. Additionally, our brains are very complex and highly interconnected. Although a wide variety of models have been proposed to model its functioning, they often only address small parts of a much larger complex system. Consider, for instance, one small piece of the puzzle, object recognition: An object might have different meanings in different contexts; it might appear with various textures

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and colors, change shape, or be assembled with other objects. The function of an object within a task also varies significantly—for instance, a wooden rod when attached to a metal part, in one context might be a hammer, yet in another context, a walking stick.

However, infants have caregivers who lend a helping hand to facilitate their learning: changing interaction patterns according to each infant's performance, so that the infant can learn useful information despite the complexity and noise in its surrounding world. Hence, infants' functional development occurs simultaneously with the development of the caregivers' skills for socially interacting with infants (Sroufe, 1988). The importance of social interaction can be seen in developmental disorders such as autism (DSM-IV, 1994), which severely damages infants' social skills. Although autistic children often seem to have normal perceptual abilities, they do not recognize or respond to normal social cues (Baron-Cohen, 1995). This asocial behaviour puts serious constraints on the information that can be passed on by a caregiver to the autistic child, and severely limits the learning process.

Human Caregivers to Teach Humanoids as Children

Therefore, in order for a robot to learn from its surrounding environment, our approach exploits a human caregiver in a robot's learning loop to extract meaningful percepts from the world (see Figure 1). Social interactions of a robot with a caregiver facilitates the robot's perception and learning, in the same way as human caregivers facilitate a child's perception and learning during developmental phases.

Furthermore, infants develop both functionally and physically as they grow. Such development is very important for infants' learning (Newport, 1990; Elman, 1993; Elman, et al., 1996). Thelen and Smith (1994) and Thelen and Ulrich (1991) address the developmental mechanisms of the brain that enable it to control the limbs and body, showing that physical development (e.g., the development of balance) and locomotor development interact during infant growth. Smith and Gasser (2005) applied such a framework to language development. In line with the motivation for work described here, Smith and Gasser (2005)

Figure 1. A caregiver as a child/humanoid robot's catalyst for learning. Left image shows a child in various learning scenarios with a human caregiver. Right image shows various experiments of a humanoid robot learning from a human caregiver.