Epigenetic Robotics

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Abstract

This lecture is about a broad research initiative that lays at the edge of computational neuroscience and robotics. Simulating and getting inspiration from biological behaviors is certainly not a new endeavor in robotics (Atkeson et al., 2000; Ballard & Brown, 1992; Sandini, 1997) and computer vision (Bulthoff, Lee, Poggio, & Wallraven, 2002) to name a few. We have taken though a novel direction which fully acknowledges the importance of embodiment and the interaction with the environment for the emergence of motor skills, perception, sensorimotor coordination, and cognition in its widest meaning (Lungarella, Metta, Pfeifer, & Sandini, 2003). In particular, our guiding philosophy – and main motivation – is that cognition cannot be hand-coded but it has to be the result of a developmental process through which the system becomes progressively more skilled and acquires the ability to understand events, contexts, and actions, initially dealing with immediate situations and increasingly acquiring a predictive capability.

As an in-detail example, we report about our investigation on action understanding in the brain. We are taking here a three-pronged approach relying on recent results of neurophysiology, on modeling of human movement, and on the implementation of the model on a robotic setup interacting in a natural environment.

Neurophysiology in the monkey has shown that action execution and action observation share a common neural basis (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996). These results provide a straightforward link between the understanding of actions and imitation. Interestingly, there is no good explanation of the ontogenesis of these responses. For this reason, we are working on computational models both on real data (recorded from a human actor) and on an autonomous robotic platform (Metta & Fitzpatrick, 2003).

We will show how this investigation delves deep into the concept of perception and action in humans and how it can cast new light on our understanding of the link between intelligence and action. Finally, we will speculate on the far reaching implications of these ideas.

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