Towards a Computational Model of an Agent's Awareness of Body and Space

Nhung Nguyen

Faculty of Technology, Wachsmuth AI Lab
University of Bielefeld
33594 Bielefeld
Germany
nnguyen@techfak.uni-bielefeld.de

1 Introduction

Understanding other's actions is supposed to help in gaining knowledge of the other's intentions [5]. Findings in neuroscience suggest that understanding the other's actions and intentions is directly related to the conscious awareness of the body [3]. Gallese defines the term *Embodied Simulation* as the usage of personal body-related experiences for modeling body-awareness, on the one hand, and on the other hand for modeling the behaviour of others. In modeling the acting body of others, we use the capabilities of our own body to simulate and understand another ones actions.

Considering these findings the following question arises: How could an embodied artificial agent develop an awareness of its own body? For building a distinctive bodily representation we propose a computational model based on the agent's (simulated) somatosensory system, namely touch and proprioception, the motor system, as well as on the visual system.

Regarding body-awareness, Gallese questions the usually sharp distinction between the mere control of the body and its awareness. Accordingly, a somatoceptively grounded body-representation, like the one we propose, yields side-effects which also have to be considered for an adequate and thorough view. This are the distinctions between *body and space* as well as between *body and others*. That means, a distinctive body representation accounts for the control and awareness of body actions within the space around the body (peri-personalspace) and the awareness of the body's relations within the world ([3], [1]). Furthermore it provides a foundation of an epistemic and cognitive self-referentiality [3].

In the following we will first present our computational model of body awareness, before considering the indicated side-effects above.

2 Towards an Agent's Body-Awareness in Space

The virtual humanoid agent Max is a situated artificial communicator for modeling and researching communicative behaviour in natural face-to-face interactions [4].

The conception of the proposed computational model is motivated by the previously introduced notions by Gallese and follows ideas presented by Breazeal et al. [2] who developed a representation of a robot's face using visual and facial muscle data. Beyond this, we follow the idea of proprioceptive, tactile and visual data forming the basis for a representation of the complete body. In previous work Max's perceptive abilities were developed including a sense of touch [6].

In our scenario, adapted from Wachsmuth [7], Max looks into a simulated virtual mirror and watches his own body. At first he has no knowledge of his body limbs, organs or body structure. When he moves his body or face, Max only perceives proprioceptive data by executing motor action, tactile stimuli by touching himself or visual stimuli by means of the virtual mirror image. In a first step, he executes random motor actions resulting in body postures while watching himself in the mirror. In this step the proprioceptive and

tactile stimuli he perceives from his body are mapped to the visual stimuli he perceives from the mirror.

Combining the sensory data, a neural network can be trained to develop a spatial representation of Max's organs and body structure. By means of this body representation, Max could now find equivalences or differences between his own body and the body of another interaction partner, e.g. an embodied agent or also a human. This could, as motivated at the beginning, enable him to simulate the behaviour of others with his own body capabilities, which is a basic foundation for understanding their actions and intentions.

In addition, according to suggestions by Anderson and Perlis, Max's perceived sensory stimuli could be organised within a somatoceptively grounded self-context, in which they are tagged with the same (self-representing) token. This self-representation including somatoception, the sense of his general shape, current disposition and cast is supposed to support a sense of his own body in space. This could also contribute to a better mapping of body- and self-related experiential knowledge and sensations, which can be regarded as the conscious awareness of the body.

3 Conclusion and Future Prospectives

Based on findings in neurosciences and previous work we propose a computational model for building a body-representation from scratch for the virtual humanoid Max, which can enable him to achieve a conscious awareness of his body. The novel aspects are the development of a representation not only for parts but for the complete body of a virtual humanoid and in addition, using data from multiple sensors from an integrated sensory system, which might be a step towards building an adequate body-representation and a body-awareness, respectively.

References

1. M. L. Anderson and D. R. Perlis. The roots of self-awareness. *Phenomenology and the Cognitive Sciences*, 4, Number 3:297–333, 2005.
2. C. Breazeal, D. Buchsbaum, J. Gray, D. Gatenby, and B. Blumberg. Learning from and about others: Towards using imitation to bootstrap the social understanding of others by robots. *Artificial Life*, 11:31 – 62, 2005.
3. V. Gallese. Embodied simulation: From neurons to phenomenal experience. *Phenomenology and the Cognitive Sciences*, Volume 4, Number 1:23–48, March, 2005.
4. N. Lessmann, S. Kopp, and I. Wachsmuth. Situated interaction with a virtual human - perception, action, and cognition. In G. Rickheit and I. Wachsmuth, editors, *Situated Communication*, pages 287–323. Mouton de Gruyter, Berlin, 2006.
5. A. N. Meltzoff. 'like me': a foundation for social cognition. *Dev Sci.*, 10(1):126134, 2007 January.
6. N. Nguyen, I. Wachsmuth, and S. Kopp. Touch perception and emotional appraisal for a virtual agent. In *Proceedings Workshop Emotion and Computing - Current Research and Future Impact, KI-2007, Osnabrueck*, 2007.
7. I. Wachsmuth. *Modeling Communication with Robots and Virtual Humans*, chapter "I, Max" - communicating with an artificial agent, pages 279 – 295. Springer (LNAI 4930), 2008.