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Special Issue on «Symbol Emergence and Developmental Systems: Social Symbol Grounding and Embodied Cognition in Humans and Robots»

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Exploring human cognitive development constitutes a basic step towards endowing robots with high-level cognitive functions so as to make them able to generate multimodal behaviors adapted to the context of interaction with human users and the surrounding environment. Embodiment of human cognition refers to the dependence of cognition on the categories of *"experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed"* [Thelen et al., 2001]. This human embodied cognition follows a seamless and gradual process of development [Vygotsky, 1978, Piaget, 1973, Fischer, 1980]. This process includes the development of sensorimotor skills**,** understanding concrete ideas and events**,** using concrete concepts representing physical entities to describe objects**,** reasoning about the implied abstract rules of problems**,** and coordinating multiple abstractions within complex representations. Investigating these aspects that bootstrap human cognitive development – through appropriate theoretical and computational cognitive modeling – allows for making robots capable of handling objects through the cumulative learning experiences that could enhance the development of sensorimotor skills**,** developing social skills through social learning strategies (e.g., imitation and emulation)**,** grounding abstract concepts in the sensorimotor system so as to define the embodied aspects of robot-environment interaction**,** and developing linguistic skills (i.e., language emergence, which depends on the development of sensorimotor and social skills, and concept grounding) in order to represent situations through language within interaction [Cangelosi et al., 2010].

A symbol system, by definition, combines a group of tokens (i.e., symbols, such as words) into structures (i.e., expressions) and manipulates them through explicit rules to produce new expressions, where all symbols are semantically interpretable [Pylyshyn, 1984]. The task of assigning a meaning to each meaningless symbol in a structure through sensorimotor interaction with the environment (similarly to the language learning and development assumptions of Skinner [1957] and others) defines the "Symbol Grounding" problem, which has long been an intensely debated issue both in cognitive science and the artificial intelligence community [Harnad, 1990]. The grounding mechanism has static physical and social components. The "Physical Symbol Grounding" allows an agent to form an internal explicit representation of an external-world referent (using sensorimotor information) so as to interpret symbols semantically [Vogt, 2002]. Whereas, the "Social Symbol Grounding" allows for developing a common lexicon of symbols grounded in perception information within a population of agents, which could lead to a gradual emergence of language through social interaction [Cangelosi, 2006]. A recent approach to semantically interpreting a symbol system is "Symbol Emergence", which accounts for the dynamic and self-organized nature of symbols that constitute human cognition (i.e., the meaning of symbols and their connecting rules could change over time) [Taniguchi et al., 2015]. These complementary representations of a symbol system are still considered as real challenges in cognitive developmental robotics, and they require more elaborate theoretical and experimental studies.

This special issue aims to shed light on cutting-edge lines of interdisciplinary research in cognitive developmental robotics at the intersection of human cognitive science, artificial intelligence, machine learning, language science, and robotics research so as to take a closer step towards better understanding the aspects of human behavior development. Recent advances and future research scope of cognitive developmental systems are discussed in detail in this journal special issue.

Topics relevant to this special issue include, but are not limited to:

- Human symbol systems and cognitive development.
- Symbol emergence in robotics.
- Cognitive modeling of human behavior.
- Language and action development.
- Learning and adaptation in cooperative human-robot tasks.
- Learning from demonstration.
- Action sequence learning.
- Affordance learning.
- Conceptual spaces for cognitive robotics.
- Fluid and embodied construction grammar for cognitive robotics.

Submission

Manuscripts should be prepared according to the journal's “Information for Authors” instructions found at http://cis.ieee.org/publications.html, and submissions should be done through the IEEE TCDS Manuscript center: https://mc.manuscriptcentral.com/tcds-ieee (please select the category “SI: Symbol Emergence”).

Timeline

Deadline for papers submission: February 20, 2017.
First notification for authors: May 20, 2017.
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Final notification for authors: July 30, 2017.

Guest Editors

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Sascha Griffiths is a research associate at the Knowledge Technology Group at Universität Hamburg. He holds an M.A. degree (2006) from Bielefeld University, Germany, and a PhD (2013) from the University of Kent, UK. He has previously held research and teaching positions focusing on social robotics and artificial intelligence at Bielefeld University, Technische Universität München and Queen Mary University of London. His current research interests include dialogue for human-robot interaction (HRI), robot safety, cognitive architectures and mind perception.

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Tadahiro Taniguchi is an associate professor at the Department of Human and Computer Intelligence, Ritsumeikan University, Japan. He received ME and PhD degrees from Kyoto University in 2003 and 2006, respectively. From April 2005 to March 2006, he was a Japan Society for the Promotion of Science (JSPS) research fellow (DC2) in the Department of Mechanical Engineering and Science, Graduate School of Engineering, Kyoto University. From April 2006 to March 2007, he was a JSPS research fellow (PD) in the same department. From April 2007 to March 2008, he was a JSPS research fellow in the Department of Systems Science, Graduate School of Informatics, Kyoto University. From April 2008 to March 2010, he was an assistant professor at the Department of Human and Computer Intelligence, Ritsumeikan University. Since April 2010, he has been an associate professor in the same department. From September 2015 to September 2016, he has been a visiting associate professor in the Department of Electrical and Electronic Engineering, Imperial College London. He has been engaged in research on machine learning, emergent systems, decentralized autonomous systems and cognitive robotics. He proposed the concept of symbol emergence system and has been conducted series of studies related to the concept. His research interests also include intelligent vehicle and language acquisition by autonomous robots.

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Paul Vogt is an associate professor at the Tilburg center for Cognition and Communication at Tilburg University in the Netherlands. He received an MSc in Cognitive Science and Engineering from the University of Groningen (Netherlands), and obtained a PhD at the Artificial Intelligence Laboratory of the Vrije Universiteit Brussel (Belgium). His research focuses on understanding the cultural, social and cognitive mechanisms that underlie the evolution and acquisition of language and communication. Prof. Vogt is particularly interested in investigating how humans (and machines) can ground the meaning of linguistic utterances in the real world, and how they learn language from each other through social interactions. To study this, he has used a variety of techniques, ranging from agent-based modeling, child-robot interaction and psycholinguistic experiments to ethnographic research of children's language acquisition in different cultures. Prof. Vogt has recently become co-PI of L2TOR, a scientific research project concerned with second language tutoring using social robots.