From Sensimotor Primitives Learned from Humans to Imitation and Manipulation Strategies in Humanoid Robots

Abstract

We want robots to become partners in our daily human environment. What kind of functions does a nice robot assistant needs to possesses and how it should learn and also look like, e.g. to become an interactive, cooperative multimodal household aid?

Our research mainly deals with the investigation of basic features for humanoid robots. For this purpose we develop technical and software solutions to perform autonomously tasks in the daily environment. The research is based on bottom up and objects based learning by explorations of visual, acoustic or haptic information observed and achieved through vision and sensory data.

Humanoid Robot

Humanoid robots include mechatronics, control and motion coordination as well as computer vision and system integration. To accomplish tasks in a household environment, the robot has to possess a wide range of abilities in the area of visual and haptic perception. These abilities comprehend, among others, the recognition and localisation of relevant objects as well as learning, how to manipulate them.

Therefore we work on different vision systems which allow the recognition of single-colored objects (e.g. recognition of dish by its shape) as well as the recognition of more complex objects using texture-based recognition methods. Furthermore it is necessary, to capture the movement of people to learn how to handle a fridge or a dish washing machine. The captured movements are used, to allow autonomous learning by observation of human activity.

To allow autonomous learning of the robots environment, we work on methods for visual and haptic exploration of objects. Active vision methods and haptic sensory information are used to learn an internal object representation from an unknown object, once it is located. The learned representation allows locating the object in a visual search task and offers information on possible manipulatory tasks.

Interactive Learning of Cognitive Capabilities

Future Humanoid and Service Robots will have to act in dynamic and unstructured environments and have to be able to adapt to them. Furthermore robots need the ability to acquire new capabilities which usually can only be specified by the end user in an intuitive and interactive way. In the context of “Programming by Demonstration” new and intelligent approaches to program robots are investigated and studied.

The development of cognitive robots relies on efficient artificial embodiments of object-action representations based on rich perceptual and motor capabilities. Thus, humanoid robots represent the most suitable experimental platform, which allows to share representations together with humans because they allow to develop perceptual, behavioural and cognitive categories in a measurable way by communicating and sharing these with humans and other artificial agents. A humanoid is supposed to interact and cooperate with humans and to enter dialogs with them. Therefore it needs to understand both, what it perceives and what it does. Our hypothesis is, that such understanding can only be achieved if we consider humans as teachers in the loop. To demonstrate the feasibility of our approach, we are building humanoid robots that learn step by step increasingly cognitive capabilities. We present recent work that combines various approaches and techniques to allow humanoid robots to interactively perform complex manipulation and grasping tasks in human centered environment and real world scenarios, like a kitchen or a living house. This includes methods for autonomous acquisition of sensimotor skills, from observation, their generalization and adaptation to new situations and contexts.

Curriculum Vitae

Prof. Dr.-Ing. R. Dillmann
Institute for Anthropomatics
Humanoids and Intelligence Laboratory
Universität Karlsruhe (TU)
Karlsruhe Institute of Technology KIT

Technologiefabrik
Haid-und-Neu-Strasse 7
D-76131 Karlsruhe

Tel: +49 (0) 721 608-3846
Fax: +49 (0) 721 608-4077
Email: dillmann [at] ira.uka.de

Prof. Dr.-Ing. Rüdiger Dillmann received a Ph. D. at the University of Karlsruhe in 1980. Since 1987 he has been Professor of the Department of Computer Science and since 2001 Director of the research group, Industrial Applications of Informatics and Microsystems (IAIM) at the University of Karlsruhe. Since 2002 he has also been director of the Research Center for Information Science (FZI), Karlsruhe. As a leader of these two institutes Prof. Dillmann supervises several research groups in the areas of humanoid robotics with special interest in intelligent, autonomous and mobile robotics, machine learning, machine vision, man-machine interaction, computer science in medicine and simulation techniques.
Prof. Dillmann is author or co-author of more than 100 scientific publications and several books. He is Coordinator of the German collaborative research center ”Humanoid Robots”, Co-Editor-in-Chief of the journal ”Robotics and Autonomous Systems”, Elsevier.