Developing cognitive capabilities for embodied robots interacting with humans

The main objective of COGNIRON is to endow robots with cognitive capacities, through the study and development of methods and technologies for perception, interpretation, reasoning, learning, and interaction with humans

Six main Research Areas

RA2: Detection and Understanding of Human Activity

(lead partner: University of Karlsruhe)

Detection and understanding of human activities is a basic capability of a robot acting in close cooperation with humans. This research activity deals with visual detection and tracking of human faces, which is one important component of this capability. Another studied component is 3D modeling of human body for detection and recognition of postures, and the interpretation of human activities based on gesture, postures, attitudes, and motions.

RA1: Multi-modal dialogues

(lead partner: University of Bielefeld)

Using language to communicate with others is one of the most important cognitive abilities of humans. Enabling dialogue capability is, therefore, essential for a cognitive robot companion interacting with humans . Since a robot is embodied and situated in the real environment, its dialogue system has to handle more complex interactions than in human computer interaction. One of the crucial aspects is the handling of multi-modality because in embodied communication human interlocutors make heavy use of gestures and other non-verbal signals and make references to the shared environment. Building a flexible dialogue system with the ability to handle multi-modal information and continuously evaluating the system during the different development cycles are the focus of this research activity.

RA3: Social Behaviour and Embodied Interaction

(lead partner: University of Hertfordshire)

In the context of HRI social behaviour and embodied interaction is an important area of research that involves numerous issues of e.g. verbal, non-verbal and affective interaction. This RA is concerned with social spaces, gestures, postures and body movements occurring in human-robot interactions and their role in research on robot motion planning, navigation and recognition of human-activities. This work aims at providing scientific insights based on experimental data on socially acceptable, primarily non-verbal behaviour. Verbal communication (dialogue) and affective factors (user comfort) are considered. Experimental data is derived from HRI user studies as well as simulation and robotics testbeds. RA3 also aims at implementing motion planners and reactive motion execution schemes, derived from user studies.

RA6: Intentionality and Initiative

(lead partner: LAAS-CNRS)

In addition to understanding its environment, to learning and to interacting with people, making decisions, be it for autonomous deliberation and task achievement, or for human-robot collaborative problem solving is a fundamental capability of a cognitive robot. This Research Area studies decision making abilities in uncertain and varying environments, as well as cognitive architectures for embodied robots, that integrates together perception, action, learning, decision-making and interaction to enable a consistent behaviour. When interacting with a robot, people tend to attribute intentions to it according to its behaviour and other factors. Studies on intentionality attribution and expression are also conducted within this RA.

RA4: Skill and Task Learning

(lead partner: EPFL)

Learning Skills and Tasks is fundamental to the development of cognitive robot companion. For the companion to show adaptive, life-long learning behaviour, it must be capable of acquiring new skills when required (e.g. change of workplace or of habit on the user's part). It must be capable of reuse (in the sense of bootstrapping knowledge) and incremental acquisition of skills through the learning of complete tasks. Imitation learning from humans is one of the main tracks investigated in this Research Area.

RA5: Spatial Cognition and multi-modal situation awareness

(lead partner: University of Amsterdam)

The objective of this Research Activity is to understand how an embodied system can come to a conceptualisation of sensory and sensory-motor data for acting, moving manipulating in typical home settings. This addresses fundamental questions of scene understanding, which include object recognition, and extraction of relationships between objects including their temporal properties. The ability to interpret situations, i.e., states of the environment and relationships between components of the environment that are static or evolving over time, using different sensing modalities, is essential for a cognitive system to assess its own state and decide its actions. For addressing open-endedness the representations are learned by means of an exploratory learning process in which human feedback plays a role.

Three Key Experiments

RA7: Systems levels integration and Evaluation

(lead partner: Fraunhofer IPA)

The integration, demonstration and validation of COGNIRON's research activities is achieved in three Key Experiments with concrete implementations on real robots in realistic settings, each focusing on one or more fundamental abilities of a cognitive robot. The demonstrations serve as integration platforms for research results and reflect research progress towards a cognitive robot companion. They provide a means for scientific evaluation.

Key Experiment 1: The Robot Home Tour
(lead partner: University of Bielefeld)

Scenario: A robot is shown to the home environment of its owner. Dialog between the owner and the robot defines the objects and places, and disambiguates interpretations. This Key Experiment stresses informational human-robot interaction and the acquisition and learning of scenes and situations.

Key Experiment 2: The Curious Robot
(lead partner: LAAS-CNRS)

Scenario: A robot interprets a person's attitude and interacts with him to understand his needs, then fetches a requested object and hands it to the person. Unknown objects encountered by the robot are modeled autonomously and named by the person. This Key Experiment stresses object learning and recognition, human activity understanding, and close physical human-robot interaction.

Key Experiment 3: Learning Skills & Tasks
(lead partner: University of Karlsruhe)

Scenario: A robot is shown by a person how to achieve a task such as arranging objects on a table. The robot learns how to achieve this task by imitating her, and reproduces the task. This Key Experiment stresses task learning and reasoning about tasks to acquire knowledge about their goals and achievements.

(photos: **KE1** -University of Bielefeld, **KE2** -LAAS-CNRS, **KE3** -Fraunhofer IPA)

Selection of Project Publications
(2004-2006)

- Raja Chatila, *The Cognitive Robot Companion and the European 'Beyond Robotics Initiative'*, 6th EAJ International Symposium "Living with Robots", October 4-5 2004, Tokyo, Japan.

- Kerstin Dautenhahn, Sarah Woods, Christina Kaouri, Michael Walters, Kheng Lee Koay, Iain Werry (2005) *What is a Robot Companion - Friend, Assistant or Butler?*, Proc. IROS 2005, IEEE IRS/RSJ Int. Conf. on Intelligent Robots and Systems, August 2-6, 2005, Edmonton, Alberta Canada, pp. 1488-1493.

- Shuyin Li, Axel Haasch, Britta Wrede, Jannik Fritsch, Gerhard Sagerer. *Human-style interaction with a robot for cooperative learning of scene objects,* Int. Conf. on Multi-modal Interfaces (ICMI2005), pages 151-158, Trento, Italy, 2005. ACM Press.

- Jannik Frisch et al., *A Flexible Infrastructure for the Development of a Robot Companion with Extensible HRI-Capabilities*, IEEE Int. Conf. on Robotics and Automation (ICRA2005), pages 3419-3425, Barcelona, Spain, April 2005.

- Michael Pardowitz, Raoul Zöllner, Rüdiger Dillmann, *Incremental Learning of Task Sequences with Information-Theoretic Metrics,* in Proc. of the European Robotics Symposium (EUROS06), March 16-18 2006, Palermo, Italy.

- Steffen Knoop, Stefan Vacek, Rüdiger Dillmann, *Sensor Fusion for 3D Human Body Tracking with an Articulated 3D Body Model*, In Proc. of the IEEE Int. Conference on Robotics and Automation, Orlando, Florida, ICRA 2006.

- Kerstin Dautenhahn, Michael L. Walters, Sarah Woods, Kheng Lee Koay, Emrah Akin Sisbot, Rachid Alami, Thierry Siméon, *How may I serve you? A robot companion approaching a seated person in a helping context*, HRI Human Robot Interaction '06 - HRI2006, Salt Lake City, Utah, USA.

- Anders Green, Helge Hüttenrauch, Kerstin Severinson Eklundh. *Applying the Wizard-of-Oz Framework to Cooperative Service Discovery and Configuration,* In Proc. of The 13th IEEE International Workshop on Robot and Human Interactive Communication, Ro-Man2004, September 20-22, 2004, Kurashiki, Japan.

- Michael L. Walters, Kerstin Dautenhahn, Kheng Lee Koay, Christina Kaouri, Rene te Boekhorst, Chrystopher L. Nehaniv, Iain Werry, David Lee, *Close encounters: Spatial distances between people and a robot of mechanistic appearance*, In Proc. IEEE-RAS Int. Conference on Humanoid Robots (Humanoids2005), Dec. 5-7, 2005,Tsukuba, Japan, pp. 450-455.

- Sylvain Calinon, Florent Guenter, and Aude Billard, (2005) *Goal-directed Imitation in a Humanoid Robot*. In Proceedings of the International Conference on Robotics and Automation (ICRA2005), Barcelona, Spain, April 2005.

- Adriana Tapus, Shrihari Vasudevan, and Roland Siegwart, (2005) *Toward a Multi-level Cognitive Probabilistic Representation of Space*. In Proceedings of the Int. Conference on Human Vision and Electronic Imaging X, part of the IS&T/SPIE Symposium on Electronic Imaging 2005, 16-20 January 2005, CA, USA. [HVEI'2005]

- Nicolas Do Huu, Williams Paquier , Raja Chatila, *Combining structural description and image-based representation for image, object, and scene recognition*, In Proc. 19th Int. joint Conf. on AI (IJCAI 2005), July30-Aug. 5, 2005, Edinburgh, Scotland

- Elin.A.Topp, Helge Hüttenrauch, Henrik.I.Christensen, and Kerstin.Severinson Eklundh, *Acquiring a Shared Environment Representation*, In Proceedings of the 1st ACM Human Robot Interaction Conference, Salt Lake City, Utah, USA, March 2006.

- Jens Kubacki & Kai Pfeiffer: *Using Range Imaging Sensors with Color Imaging Sensors in Cognitive Robot Companions: A New and Simple Calibration Technique Based on Particle Swarm Optimization*, Proc. 1st Range Imaging Day, pp. 43-58, Zurich, 2005.

- Efrain Lopez-Damian, Daniel Sidobre, and Rachid Alami, *Grasp Planning for Non-Convex Objects*, 36th International Symposium on Robotics- ISR2005, Nov-Dec 2005, Tokyo, Japan.

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- Aurelie Clodic, Vincent Montreuil, Rachid Alami and Raja Chatila, *A Decisional Framework for Autonomous Robots Interacting with Humans*, in Proc. of IEEE Int. Workshop on Robot and Human Interactive Communication RO-MAN 05

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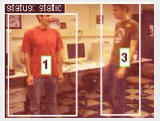





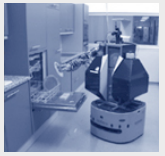

'Developing robots interacting with humans, able to perceive, decide, communicate and learn in an open-ended way'

COGNIRON

The Cognitive Robot Companion

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