

Dear Readers,

Cognitive systems integrate numerous constituent processes. Unlike chemists, who have been able to close their books in their search for new elements for almost a century (and have arrived at clear characterizations of their elements), we are still groping for characterizations of the “elements of cognition” and are still further away from a principled and systematic picture that could rival that of the periodic table of elements in chemistry. Admittedly, our elements are much more complicated and should be conceptualized as processes of interaction instead of static entities. Two candidates for such processes, the ability to navigate, and the ability to manipulate deformable objects, are the subject of two contributions in this issue. Numerous other candidates are the focus of cognitive systems research around the world. But what are the principles that govern the assembly of these constituents into architectures that manage to qualify as “cognitive” in the critical eye of the human beholder? Encouraging progress can be seen to come from scaling up search processes in large databases or extracting emergent semantics from social networks. Will this lead us to our desired understanding of cognition, or is it more akin to an alchemist’s success of finding porcelain in his quest for gold? We don’t know yet—but it certainly seems like we live in an exciting time that is approaching the dawn of a systematic “chemistry of cognition”,

sincerely yours,
Helge Ritter, Coordinator

CITEC NEWS

- ▶ The Service Scientifique of the French Embassy in Germany and CITEC are jointly organizing a workshop “Perspectives on Cognitive Interaction and Technology” to be held during June 4–5 2012 in Bielefeld. Aim of the workshop is to bring leading French and German researchers in fields pertinent to cognitive interaction together in order to exchange ideas for future perspectives and explore possibilities of bi-national cooperation.
- ▶ Adding the roof to the new CITEC research building was celebrated on February 23. The completed shell of the 32 million Euro building gave a first glimpse at how the new home for laboratories and offices will look.
- ▶ CITEC contributed two robots to the exhibition “distant companions” in Mannheim’s Reiss-Engelhorn Museum of World Cultures that celebrated 150 years of German-Japanese relations. The two robots were part of a joint exhibit with CITEC’s cooperation partners at Osaka university.
- ▶ New CITEC research group ‘Neuromorphic Circuits’ headed by Elisabetta Chicca, formerly ETH Zurich, is now operational. The group aims to explore the computational capabilities of large networks of recurrently connected neurons using biologically inspired electronic systems.
- ▶ Together with an interdisciplinary team of artists, designers and journalists, Thomas Hermann of CITEC’s Ambient Intelligence Group has launched the online media art project #tweetscapes to sonify the German-speaking twitter network. Learn more at <http://tweetscapes.de>
- ▶ CITEC PhD student Paper Alexa Breuing has received the Best Student Paper Award at the 4th International Conference on Agents and Artificial Intelligence for the paper “Let’s Talk Topically with Artificial Agents! Providing Agents with Humanlike Topic Awareness in Everyday Dialog Situations” that she wrote together with her doctoral advisor Prof. Dr. Ipke Wachsmuth, head of CITEC’s Artificial Intelligence Group.
- ▶ CITEC’s Kirsten Bergmann received the doctoral dissertation award bestowed by the Westphalia-Lippe University Society acknowledging the exceptional quality of her dissertation thesis.
- ▶ <http://www.cit-ec.de/news>

The new research building for CITEC – A physical instance of interdisciplinary research



Interdisciplinary research has been a hallmark of Bielefeld University from its very beginning—more than four decades ago. The idea to have all disciplines under one roof has worked out in terms of short communication pathways and a seamless scientific interaction between researchers who are rooted in different faculties. As a result of these processes, the CITEC initiative started with 15 research groups and—up to now—has brought together 37 groups that operate about 35 laboratories.

The overall vision of CITEC is an integrative approach towards the understanding of cognition in humans and other biological systems that inherently includes its synthesis in technical systems—such as robots. Essential elements are joint interdisciplinary experiments, the recording of datasets that are analyzed across disciplines, the transfer from basic research to usable technical systems, which in-turn are working as research platforms for multiple disciplines.

To further optimize its infrastructure CITEC developed a detailed plan for a larger, dedicated research building that has been carefully tailored to the needs of CITEC's long-term research agenda. The concept has been submitted within a dedicated funding line provided by the German Federal Government and the Federal States. Acknowledging its

exceptional quality, the concept was ranked first among 100 competitors by German Council of Science and Humanities (Wissenschaftsrat) and received funding of 32 million Euro.

The construction of the research building "Interactive Intelligent Systems" started in January 2011 and is expected to be finished in October 2012. It is positioned as a central element of the new Campus North. This is a large area in walking distance to the university main building. The research building will provide 5,300 m² of space including a laboratory landscape of 1,300 m² that is mainly organized around a central laboratory on the ground floor. This enables a new level of cooperation and interaction between research groups. Technology can be more easily transferred between specialized and integrated setups. Instrumentation can more effectively be shared (e.g. EEG laboratories, motion capture systems, sensor-actor rooms, etc.). The central laboratory will host a highly integrated instrumentation environment that allows to simulate and to capture cognitive processes in high-resolution using virtual environments, capturing technology, and physical robotic platforms. A further special feature of the building is an integral residential apartment for experiments in domestic settings. It combines service robotics with ambient

assistive living elements and provides a realistic environment for interaction studies with humans. The 'Central Lab Facilities' (CLF) have been founded as dedicated scientific unit that maintains and further develops this exceptional research infrastructure. Until end of the year, the research building will start to host 17 research groups from the disciplines of informatics, engineering, linguistics, psychology, and sports science. It will be completed by a conference center for nearly 200 participants that is planned as an internationally visible hallmark of this profiled research site.

It's OWL: CITEC researchers contribute to newly funded Leading-Edge Cluster



In January the Federal Ministry of Education and

Research chose the cluster "Intelligent Technical Systems (It's OWL)" as one of four winning entries in its leading-edge cluster competition. The initiative is set to boost Germany's innovative strength and economic success through strategic partnerships between business and science. The cluster's focus will be on innovation in the fields of mechatronics and systems with inherent partial intelligence. The aim is to strengthen the global market position of the mechanical, electrical and electronics industry. "It's OWL" is being funded with 40 million Euros over the next five years and participants include 127 businesses, 16 universities and higher education facilities as well as 30 economy-related organizations.

Bi-manual robotic paper manipulation based on real-time marker tracking and physical modeling



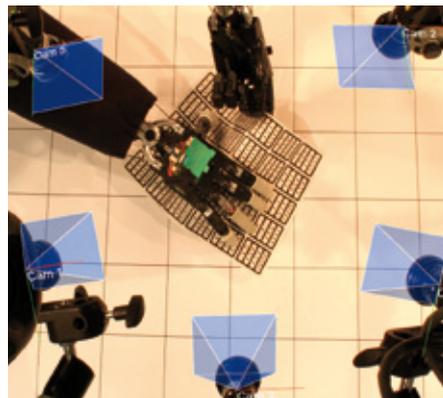
Top view of the calibrated five camera setup / anthropomorphic robots hands interacting with paper.

The challenge of grasping and manipulating rigid objects with multi-fingered robot hands has seen much progress in recent years. However, many objects, such as textiles, food and paper are non-rigid, making their shape very difficult to predict. This makes it extremely hard or impossible to use geometry-based planning methods for the handling of such objects with robot hands. Consequently, robotic manipulation of highly deformable objects is largely still an unsolved problem.

An interesting, useful and rich domain for studying grasping and manipulation strategies for such situations is the manipulation of paper. CITEC researchers believe that a thorough understanding of manipulation strategies for paper and their reproduction on multi-fingered robot hands will be a significant step towards a synthesis of the "manual intelligence" [2] that can be seen at work when handling non-rigid objects with our own, human hands.

For this project, the authors focused on the control of the multi-fingered, anthropomorphic Shadow Robot Hands in the CITEC grasplab setup. Since reliable geometry information and haptic feedback is not available, camera based methods to gather scene information had to be used.

As a first step the researchers investigated a simple interaction scenario in which a sheet of paper was picked up bi-manually by the robot hands. Although at first glance this seemed to be a very simple task, in fact it had not yet been solved for anthropomorphic robot hands.



Scene overlaid with physical model. Left robot hand grasps the paper bulged up by the right hand.

The developed system consisted of three building blocks: visual detection, physical modeling and vision guided robot control. To facilitate visual detection and to compensate for the lack of reliable haptic feedback, fiducial markers were used covering both sides of the sheet of paper. The visual detection was performed using five calibrated cameras.

This provided a huge set of 3D-reference points and also helped overcome severe occlusions from the robot hands and from the paper itself. The physical modeling was implemented using the Bullet-physics engine, which provides soft body physics models. The major difficulty in this step was to establish a 'link' between the physical model of the paper and the sheet of paper itself.

The CITEC researchers developed a velocity based control method to iteratively move the vertices of the physical nodes in the model towards their counterparts in the real scene in real-time. Nodes that were not detected due to occlusions were interpolated smoothly using Bullet's built in physical model properties such as stiffness, collision and surface distance preservation.

Once the detection and modeling framework was completed, it was used to enable the robot system to pick up a sheet of paper that was lying on a table. First, the right hand was used to bulge up the sheet of paper. Then, the optimal direction and position for grasping the paper with the left hand was estimated in order to be able to lift it up. Future directions for this project will concentrate on more complex interaction patterns such as paper folding. For this, the physical model will need to be extended to handle folds. The computer vision algorithms such as camera calibration, fast marker tracking, 3D geometry and visualization are part of the open source "Image Component Library (ICL)" (www.iclcv.org) developed at CITEC.

Elbrechter C, Haschke R, Ritter H (2011). *Bi-Manual Robotic Paper Manipulation Based on Real-Time Marker Tracking and Physical Modelling*. International Conference on Intelligent Robots and Systems (IROS 2011). San Francisco, California.

Dipl. Inf. Christof Elbrechter is a PHD student in the CITEC Neuroinformatics Group headed by Prof. Dr. Helge Ritter. Dr. Robert Haschke, leads the Robotics subgroup within the Neuroinformatics Group.

Research group: Sociable Agents



The Sociable Agents group at CITEC investigates how technical systems can be endowed with the “interaction intelligence” necessary to join and assist humans in natural, socially apt ways. The group is headed by apl. Prof. Dr.-Ing. Stefan Kopp. Stefan obtained his Ph.D. from Bielefeld University in 2003. After post-doctoral research at Northwestern University (USA), he returned to Bielefeld to become a senior research assistant at the A.I. Group and in 2005/2006 a research fellow at the Center for Interdisciplinary Research (ZiF). Stefan received tenure in 2008 and became Adjunct Prof. in the Faculty of Technology in 2010. He is currently president-elect of the German Society of Cognitive Science (GK), member of the editorial board of international journals such as *Cognitive Processing* or *GESTURE*, as well as of steering or program committee member of the main conferences (IVA, AAMAS).

Research Interest

The group’s research aims to identify and to model the behavioral and cognitive building blocks of how humans interact with each other in face-to-face settings. Specifically, the group investigates the following questions: How to build artificial

conversation partners that can flexibly produce and robustly understand multimodal socio-communicative behavior? How to enable them to participate in the dynamic process of jointly constructing a dialogue? What are the sensorimotor as well as social cognitive mechanisms of embodied conversation and task-oriented collaboration? How to bootstrap such abilities by means of data-based observational modeling and learning in interaction itself? Pursuing these issues the group builds integrated embodied conversational agents and employs them for experimentation and evaluation, as well as for creating novel human-machine interaction scenarios in which they are to provide not only utility but also easy access and comfort to users. The practical use of such systems is explored in projects with partners such as the von Bodelschwingh Foundation (Bethel) or Harting Corp.

Current Research Projects

- Autonomous speech and gesture generation from visuospatial imagery
- Adaptive and incremental behavior generation architectures for multimodal agents
- ‘Attentive speakers’: Online under-

standing of and adaptation to listener feedback

- Bayesian approach to modeling conversation partners
- Hierarchical Bayesian models of gesture processing ranging from motor structures to levels of communicative meaning, used for both perception and generation of gestures, simulation of automatic entrainment due to top-down/bottom-up resonance effects
- Sequential probabilistic models for fast and online learning of interaction data
- Embodied action tutoring: efficiency of instructions for complex manual actions given by a virtual human using speech and gesture
- Personalized virtual assistant for elderly and people with special needs, and its social acceptability
- Web-based dialogue system for guided product configuration

Collaborations

- Institute for Social Psychology, U. Duisburg-Essen
- MPI for Psycholinguistics, Nijmegen
- School of Communication, Northwestern University
- Telecom ParisTech (CNRS), Paris
- Institute for Creative Technology, USC Los Angeles
- Human-Media Interaction, University of Twente
- CADIA Lab, Reykjavik University
- International Computer Science Institute (ICSI), UC Berkeley
- Union College, NY



Gender Mainstreaming and Diversity Management at CITEC (2008–2012)

CITEC is dedicated to excellence through innovative and sustainable Gender Mainstreaming and Diversity Management. CITEC seeks to recruit female researchers and to raise the percentage of female scientists in leading positions. These strategic aims are complemented by presenting innovative perspectives to change stereotypical gender- and science-specific roles. CITEC provides for better reconciliation of scientific work and family life and endeavours to advance gender equality and diversity-oriented transformation processes in science in general.



To this end, a CITEC Gender Mainstreaming and Diversity Management Office was established in 2008. Since then, a wide range of projects and programs have been developed, all preceded by detailed assessment of needs and accompanied by regular evaluations. The programs are target-group-specific and modular in structure and designed for the long-term support of the scientists. Some projects were carried out in cooperation with Bielefeld University.

To underline its commitment to gender equality, CITEC established a junior research group "Gender and Emotion in Cognitive Interaction Technology". CITEC has also allocated funds of 0.5 lecturer positions in faculties that appoint women to professorships.

The following statistics illustrate the effective fostering of Gender Equality at CITEC: out of all CITEC funded new research groups, 45% are headed by women and female researchers were appointed to 75% of new W1 professorships.

CITEC-Programs for Executives

Following a preparatory needs analysis and individual interviews, the Structured Program for Executives for female scientists was offered between 2008 and 2010, with the goal of increasing the percentage of female scientists in leading positions. The program's modular design allowed it to flexibly adapt to the needs of the interdisciplinary group of participants. After conducting guideline-based interviews with research group leaders in 2010, the Gender Mainstreaming and Diversity Management Office started its second program for



executives, TRANSFER, in January 2012. This program supports male and female scientists in all relevant fields of leadership and supervising competences and work-life-balance.

CITEC-Mentoring-Program: MentScience

CITEC created the inter-disciplinary, inter-faculty and diversity-oriented mentoring program MentScience for the gender-oriented promotion of young female researchers. In addition to a qualified and effective career planning service, MentScience fosters interdisciplinarity.

MentScience has collaborated with the Bielefeld Excellence Graduate School and the Bielefeld Research Institute for Cognition and Robotics (CoR-Lab), and was supported by an international group of renowned top level mentors. It also cooperates with the Bielefeld University Mentoring-Program Movement, currently within a new Movement-Mentoring-Program for female Post-Doc scientists.

Bi:tasteMINT

The Gender Mainstreaming and Diversity Management Office designed the program Bi:tasteMINT, to motivate female high-school students to start an academic career in one of the MINT subjects: mathematics, informatics, natural or technical sciences. It is based on the national tasteMINT program which is designed to assess individual potential in the MINT subjects. School-girls in their final year participate in an assessment center with exercises derived from the MINT-sciences. They receive extensive feedback and a first-hand insight into student life, for example at the Bielefeld teutolab robotik. A winner of a nationwide competition in 2010, Bi:tasteMINT is carried by the DFG funded CRC 673 "Alignment in Communication" of Bielefeld University in close cooperation with CITEC.

For a better reconciliation of scientific work with family life, CITEC supplies its scientific employees with a range of measures, including a children's office for ad-hoc childcare, assistance for scientific employees returning from maternity leave or parental leave, and through the refunding of travel, accommodation and babysitting expenses to support scientific mobility.

CITEC provides its scientists with gender consulting, as well as personal counselling and individual coaching. On request, modules for gender equality measures are individually drawn up for third-party-funded research projects.

Future prospects

CITEC will continue its efforts to further increase the overall proportion of women. The above programs will be maintained in close cooperation with the university, supplemented by key aspects such as Intercultural Competence in Science and complemented by new programs designed along Diversity Management lines.

Ursula Keiper is advisor for Gender and Diversity at CITEC www.cit-ec.de/GenderDiversity

No Need for a cognitive map: Decentralized memory for insect navigation



Model of six-legged robot HECTOR

What makes a system, artificial or natural, a cognitive one? This question has been stimulated by an experimental paradigm not immediately prone to be in the focus of studies concerning cognition. In these experiments performed with honey bees and desert ants it has been tested how these animals find food sources and the way back to their nest. When desert ants search for food, they often have to cover long distances, more than ten thousand times their body lengths, and then return home and find the nest entrance. Many experiments show that these animals employ a skylight compass including the sun, a pedometer, and a mechanism called path integration. This means that during walking they continuously update the vector pointing from their actual position back to the nest site. In addition they use landmarks. However, based on studies on the behavior of ants and honey bees several authors have argued that these animals are employing a neural system that is able to represent frequently visited locations in the form of a "cognitive map". Such a map-like system would enable the animal to find a shortcut between two separately learned locations without having learned this direct path between

both locations before. As such shortcuts have been observed, cognitive maps are assumed to exist.

Using artificial neural networks, CITEC researchers have developed an artificial memory system called Navinet, which is based on path integration and various landmark guidance mechanisms. This memory consists of a bank of individual and independent procedural memory elements, each representing an association between visual input (landmarks) and motor output (walking direction), thus comprising a completely decentralized architecture. Retrieval of individual memory elements depends on a separate motivation network providing the specific context.

The team could show that an agent, which will be implemented in the CITEC robot HECTOR, controlled by this network, is able to accomplish various navigational tasks known from ant and bee studies. The most critical task is to find new shortcuts, a property, as mentioned, often discussed as requiring a cognitive map.

As this network can be characterized as a reactive system, it seems not sensible to call it "cognitive". But how may cognition be defined? Maturana and Varela (1980) say "Life is Cognition".

Other authors characterize a cognitive system as one whose behavior cannot be predicted by an observer even with full knowledge of the sensory input. Such a definition would include a random generator-driven system. A more interesting definition is given by McFarland and Bösser (1993): A cognitive system allows for exploitation of memory elements independent of the context in which these elements have been acquired. In other words, a cognitive system allows for playing internally with different combinations of memory elements (see also S. Freud, "probehandeln" 1914).

Within the EU project EMICAB such cognitive abilities are planned to be implemented in HECTOR, but are clearly not a capability of Navinet. Rather, in Navinet a map-like behaviour as observed in desert ants and honey bees arises as an emergent property from a decentralized, reactive system. Cognition is not required to explain this behaviour.

Cruse H, Wehner R (2011) *No Need for a Cognitive Map: Decentralized Memory for Insect Navigation*. *PLoS. Comp Biol* 7(3): e1002009.

Holk Cruse is Senior Researcher at CITEC, Rüdiger Wehner is Professor at the Brain Research Institute at the University of Zurich.

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