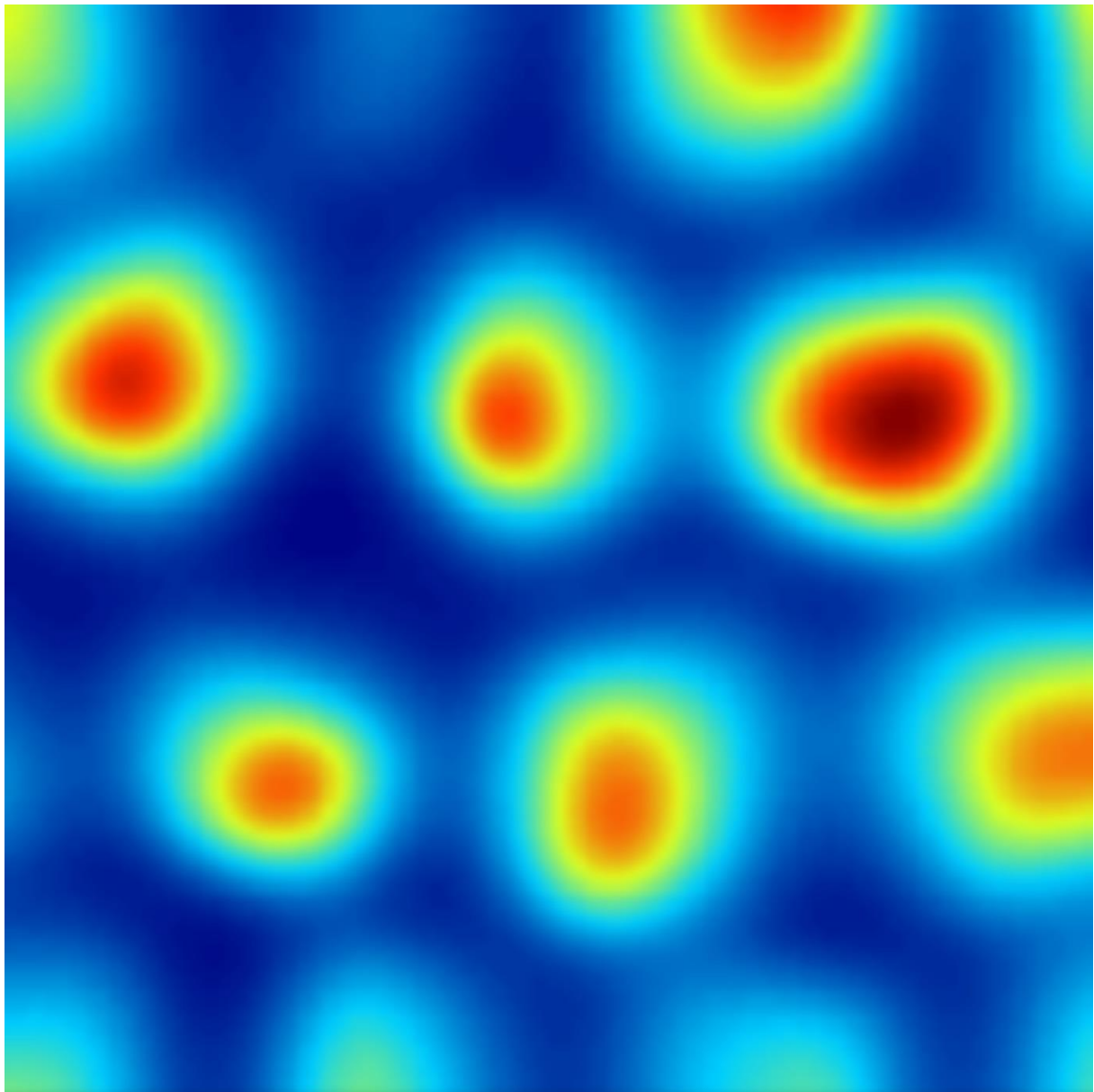


Research Report 2010 – 2013  
Human-Computer Interaction  
FernUniversität in Hagen



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The cover image shows a firing rate map of a simulated grid cell of a rat brain (taken from J. Kerdels, G. Peters, "A Computational Model of Grid Cells based on Dendritic Self-Organized Learning", NCTA 2013.)

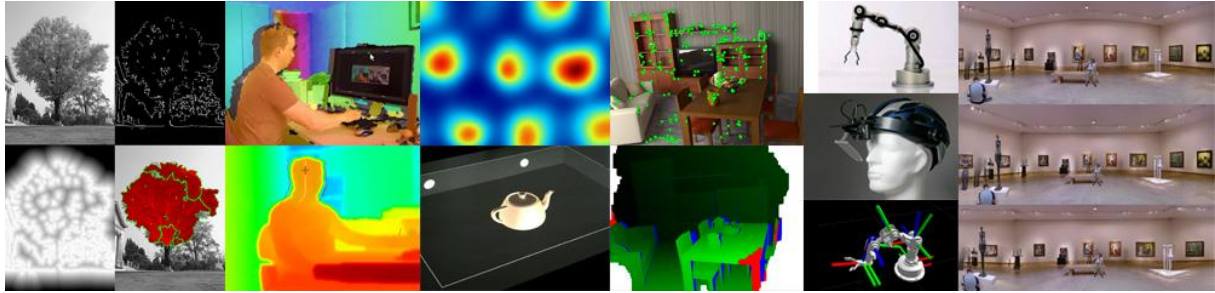
Research Report 2010 – 2013  
Human-Computer Interaction  
FernUniversität in Hagen  
Prof. Dr. Gabriele Peters

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Facilities and Results from the HCI Group.

## 1 Results

Research at the Chair of Human-Computer Interaction (HCI group) at FernUniversität in Hagen is focused on the **investigation and development of interactive and intelligent systems**. Cooperating with researchers around the world, the group is active in basic as well as applied research. The underlying motivation on the part of **basic research** is the big question of the nature of consciousness. Here the group is interested in the **investigation of intelligent biological systems** by means of theory building as well as simulations on computers and robotical systems. More concrete, the HCI group aims at gaining deeper insight into particular aspects of human or animal cognition, such as vision or spatial cognition. The main goal on the part of **applied research** is the **development of intelligent computer systems** that interact with humans in an intuitive and multimodal way.

The HCI group's activities are located around the following core areas:

- Interactive Systems
- Computer Vision
- Image & Scene Synthesis
- Cognitive Systems
- Computational Neuroscience
- New Media Art

These areas are closely interrelated. Most of the projects address more than one of these topics at the same time. Furthermore, results from basic areas such as Computational Neuroscience often fertilize the development of future technologies such as self-learning, adaptive computer systems.

The field of Human-Computer Interaction is profoundly **interdisciplinary** with links to such diverse fields as the cognitive sciences and brain research as well as the visual arts, design theory, and aesthetics. Beyond the above mentioned core areas of active research the group is interested in the philosophy of mind and in questions of ethics in the context of future technologies.



**Results from a Projector-Camera Project.** Left: Colored depth image with detected 3D head position of a user. Middle and right: Two different views of a projected object depending on the user's head position. Images from Garstka & Peters, "View-dependent 3D Projection using Depth-Image-based Head Tracking", PROCAMS 2011.

## 1.1 Interactive Systems

The concept of interaction is relevant for research at the HCI group in a twofold way. On the one hand, it is relevant for **basic research**. Recent results from the fields of cognitive robotics and the philosophy of mind suggest that the interaction of an embodied agent with its environment is crucial for consciousness to arise. On the other hand, the concept of interaction is relevant from the **application** point of view. Here the group is concerned with the development of computer systems which are able to interact with humans in a natural way. Such systems are supposed to adapt to their environment and especially to human needs, rather than expecting an adaption of humans to the restrictions of an artificial system. To this end an interactive system has to be capable to **actively explore, perceive, and understand its environment**. Yet unsolved problems in this field of research consist in the **fusion of methods** and techniques formerly separated into the distinct fields of Computer Vision, Computer Graphics, or Machine Learning and the development of **multimodal forms of interaction** between humans and computers.

### Results

Within the scope of a DFG-funded project (Pe-887) the HCI group developed a system for the **reconstruction of 3D objects** from **a few snapshots taken freehand** with a simple consumer camera. It allows users to obtain a 3D model of an object in an **interactive** and flexible manner. During the reporting period this system was developed further and the group was successful in improving it in terms of speed and robustness. The **freehand acquisition software was published** under a Creative Commons license and is publicly available from [www.fernuni-hagen.de/mci/resources/](http://www.fernuni-hagen.de/mci/resources/). Within a framework of another project a flexible display was developed, realized by a **projector-camera system**. It projects images of objects on plain surfaces such as table tops or walls and takes the position of a user into account to convey a 3D impression of the displayed objects. Furthermore, by means of the development of a prototype, the possibilities of **eye gesture- and head gesture-controlled interfaces**



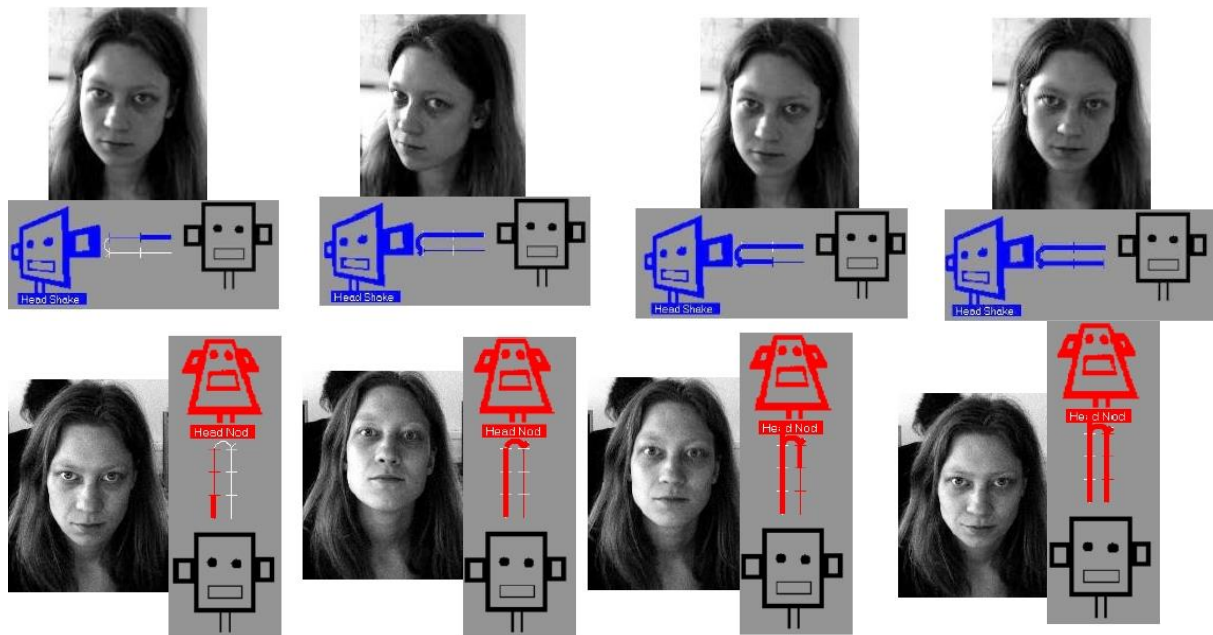
**for support of physically impaired persons** have been investigated in a cooperation with TU Dortmund University.

### Publications

- Jens Garstka and Gabriele Peters, "View-dependent 3D Projection using Depth-Image-based Head Tracking", 8th IEEE International CVPR-Workshop on Projector-Camera Systems (PROCAMS 2011) in conjunction with IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2011), Colorado Springs, USA, June 24, 2011.
- Gabriele Peters and Klaus Häming, "Fast Freehand Acquisition of 3D Objects and their Visualization", Journal of Communication and Computer, Vol. 7 (3), 2010.

### Talks and Presentations

- Gabriele Peters, "From Human to Computer and Back Again - Selected Projects from the Field of Human-Computer Interaction", talk, Institut für Wirtschaftsinformatik, Westfälische Wilhelms-Universität Münster, Münster, Germany, July 09, 2013.
- Gabriele Peters, "Barrierefreie Interaktion mittels Blick- und Kopfverfolgung und Freihanderfassung von 3D-Objekten", demonstrations in the course of on-site inspections for accreditation, FernUniversität in Hagen, Germany, January 18, 2013.
- Gabriele Peters, "Mensch-Computer-Interaktion an der FernUniversität in Hagen", talk, Strategy Workshop of the Management Board of the GI-Group *Computer Graphics*, Fontanella, Austria, March 22, 2012.
- Gabriele Peters, "Interaktionen mit einem Roboter-Kamera-System, einem mobilen Eyetracker und einer Tiefensensor-Kamera", demonstrations in the course of on-site inspections for accreditation, FernUniversität in Hagen, Germany, December 8, 2011.
- Jens Garstka, "View-dependent 3D Projection using Depth-Image-based Head Tracking", talk, CVPR-Workshop PROCAMS 2011, Colorado Springs, USA, June 24, 2011.
- Gabriele Peters, "Vom Mensch zum Computer und zurück - Über die Entwicklung interaktiver Systeme", Inaugural Lecture, FernUniversität in Hagen, Germany, November 20, 2010.



**Interaction for the Physically Impaired, Head Gesture Recognition Serving as Input for Interactive Systems.** Upper row: Recognition of head shake. Lower row: Recognition of head nod. Blue and red bars indicate the detected head movement. Images from Kathrin Rösner, “Combining Eye Tracking and Head Tracking For Hands-free Human-Computer Interaction”, diploma thesis, 2012, in cooperation with Prof. Dr. H. Müller, TU Dortmund.

## 1.2 Computer Vision

One goal of Computer Vision is the **analysis of information extracted from images with the purpose of understanding their content**. As mentioned before, one of the demands made on interactive systems is the ability to perceive and understand their environment. Thus, Computer Vision provides the visual modality of **automatic scene understanding**. A major challenge of Computer Vision consist in **object recognition and classification**. This means the decision which individual objects are present in an image and the assignment of an object to a special category, respectively. Another challenge is posed by the handling of **huge and high-dimensional input data spaces**. To manage continuous video streams of an interactive system, for instance, the huge amount of data provided by the environment is supposed to be processed faster and **in a more intelligent way** than with current methods. To master these challenges of interactive systems such as big data and real-time processing, learning and recognition should not be regarded as two separated, sequential processes, but **learning to recognize** or classify objects is supposed to be incremental and should persists while a system is in the field already. An open subject of investigation in the field of object recognition is **recognition by interaction**. Interactive systems should be able to foster their recognition abilities by an active exploration of their environment. In any case, interaction will be a key issue also in the field of Computer Vision.

## Results

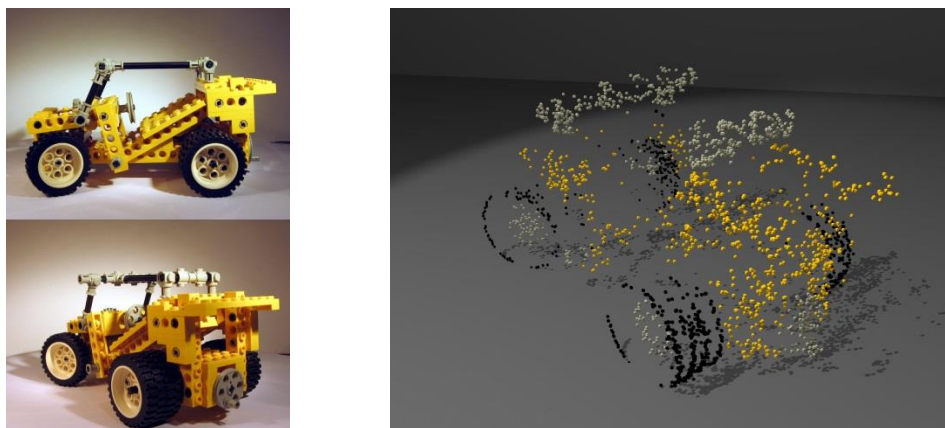
In several experiments the HCI group examined the possibilities to apply **different machine learning techniques** such as relational reinforcement learning **in computer vision tasks**. In one experimental setting a prototype was implemented that is able to recognize an object from its appearance only, without further knowledge such as camera parameters, and despite the fact that at any one time very similar, alternative objects are available. In another setting a system was developed that learns to autonomously select only those views of an object for its recognition decision that allow for a reliable recognition. This prototype can be regarded as an **autonomous agent** which is able to **learn from past experiences** as well as to **acquire new knowledge from its environment**. The fact that the system is able to **utilize the learned knowledge successfully in object recognition tasks** can be regarded as a proof of concept for the general applicability of the group's learning approaches in computer vision applications.

## Publications

- Klaus Häming and Gabriele Peters, "A Hybrid Learning System for Object Recognition", Proceedings of the 8th International Conference on Informatics in Control, Automation, and Robotics (ICINCO 2011), edited by J.-L. Ferrier, A. Bernard, O. Guskhin, and K. Madani, SciTePress, Vol. 2, pp. 329-332, Noordwijkerhout, The Netherlands, July 28-31, 2011.
- Klaus Häming and Gabriele Peters, "Learning Scan Paths for Object Recognition with Relational Reinforcement Learning", 7th International Conference on Signal Processing, Pattern Recognition and Applications (SPPRA 2010), edited by B. Zagar, A. Kuijper, and H. Sahbi, ACTA Press, Innsbruck, Austria, February 15-19, 2010.

## Talks and Presentations

- Klaus Häming, "A Hybrid Learning System for Object Recognition", poster presentation, ICINCO 2011, Noordwijkerhout, The Netherlands, July 28, 2011.
- Klaus Häming, "Learning Scan Paths for Object Recognition with Relational Reinforcement Learning", talk, SPPRA 2010, Innsbruck, Austria, February 16, 2010.



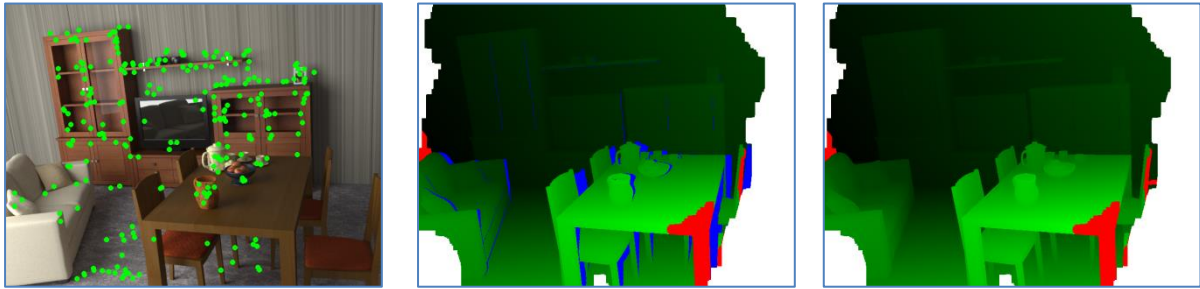
**3D Object Acquisition.** Left: Examples for views of an object. Such images serve as input for the acquisition algorithm. Right: 3D point cloud resulting from such object views.

### 1.3 Image & Scene Synthesis

The concern of image & scene synthesis is the **generation of visual presentations of information**, namely in the form of 3D scenes, 2D images, or videos. One purpose of **image synthesis** can be **data analysis**. In such visualizations the data presentation should allow for the recognition of patterns or relations between data by the human eye. On the other hand, the major domain of **scene synthesis** is interaction and scene understanding. To interact with the world a system needs internal representations of the world. Thus, this field of research aims at **capturing the real world and transforming it into a virtual world**. As such, scene synthesis constitutes the foundation for key elements of an interactive system such as navigation, or localization and manipulation of objects in the environment. Hence one of the most important technologies in the future will be **3D reconstruction techniques**, that map the real world to a virtual world. Yet unsolved problems in this domain consist in an intelligent **acquisition of the real world**, appropriate **parameterizations of 3D scenes**, and **object descriptions** suitable for efficient synthesis, display, and manipulation.

#### Results

In the reporting period the HCI group has been active in the fields of **3D object acquisition**, **3D scene reconstruction**, and **2D visualization**. In the context of acquisition of 3D object information from uncalibrated 2D images the group developed a **new mathematical approach** which represents a simplification of the state-of-the-art acquisition process. Whereas in the conventional approach triplets of images are necessary, the proposed approach gets along with pairs of images only. On the bottom line, the group's approach needs **less input images** and thus proceeds **in a faster way** without a reduced quality of the resulting object description. One of the students of the HCI group received the **3rd award for**



**3D Scene Reconstruction with Improved Stereo Matching.** Left: Feature points overlaid on a scene to be reconstructed. Middle and Right: Estimated disparity space; middle: earlier iteration step, right: final result. Blue: no estimation, red: wrong estimation, green: correct estimation. Images from Christoph Drexler, "Beleuchtungsinvariante und rauschinsensitive Disparitätskartenberechnung", master thesis, 2012.

**the best paper** at the *Informatiktage 2012* for his contributions to this project (see section 2.2). In another project the group could contribute to a step forward to more trustful computer systems in safety-critical environments. **Together with researchers from the Universities of Groningen, Bielefeld, and Marburg** internal, dynamic processes of one of the group's self-learning systems (see also section 1.4 on Cognitive Systems) have been visualized as a means for providing **more salient feedback to system operators**. Furthermore, **an algorithm for stereo matching has been developed that reduces the computing time for the reconstruction of 3D scenes**. This could be achieved by an adaptive estimation of the search space for corresponding scene points in two different views of a scene depending on the image content. Also in this project one of the group's students received a **nomination for the best paper award** at the *Informatiktage 2013* for his contributions (see section 2.2).

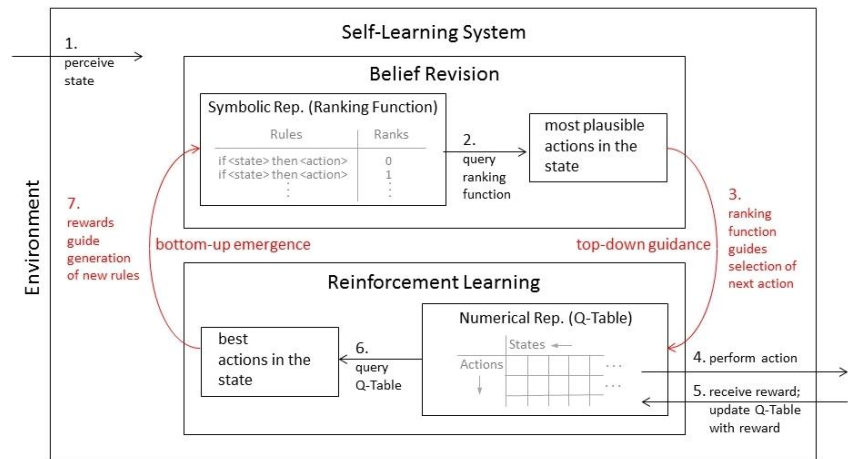
## Publications

- Sergey Cheremukhin, "Zuverlässiges Structure-From-Motion für Bildpaare", Informatik Spektrum, Springer, Vol. 36 (4), pp. 382-388, 2013.
- Christoph Drexler, "Abschätzung des Disparitätsraumes für das Stereo-Matching mithilfe von Bildmerkmalen", Informatiktage 2013, Lecture Notes in Informatics, Vol. S-12, pp. 205-208, Gesellschaft für Informatik, Bonn, Germany, March 22-23, 2013.
- Gabriele Peters, Kerstin Bunte, Marc Strickert, Michael Biehl, and Thomas Villmann, "Visualization of Processes in Self-Learning Systems", 10th Annual International Conference on Privacy, Security and Trust (PST 2012), IEEE Computer Society, pp. 244-249, Paris, France, July 16-18, 2012.
- Sergey Cheremukhin, "Vereinfachte 3D-Rekonstruktion aus Sequenzen unkalibrierter Bilder", Informatiktage 2012, Lecture Notes in Informatics, Vol. S-11, pp. 183-186, Gesellschaft für Informatik, Bonn, Germany, March 23-24, 2012.
- Klaus Häming and Gabriele Peters, "The Structure-from-Motion Reconstruction Pipeline - A Survey with Focus on Short Image Sequences", Kybernetika, Vol. 46 (5), pp. 926-937, 2010.

## Talks and Presentations

- Christoph Drexler, "Abschätzung des Disparitätsraums für das Stereo-Matching mit Hilfe von Bildmerkmalen", talk, Informatiktag 2013, Bonn, Germany, March 22, 2013.
- Klaus Häming, "Visualization of Processes in Self-Learning Systems", talk, PST 2012, Paris, France, July 16, 2012.
- Sergey Cheremukhin, "Vereinfachte 3D-Rekonstruktion aus Sequenzen unkalibrierter Bilder", talk, Informatiktag 2012, Bonn, Germany, March 23, 2012.
- Gabriele Peters, "Visualization of Learning Processes – A Problem Statement", talk, Dagstuhl-Seminar 12081 "Information Visualization, Visual Data Mining, and Machine Learning", Schloss Dagstuhl – Leibniz Center for Informatics, Germany, February 22, 2012.





**Cognitive Architecture Inspired by Psychology.** Left: Concepts of human learning serving as inspiration for a proposed system. Top left: *Explicit or top-level (conscious) learning* such as learning vocabulary. Bottom left: *Implicit or bottom-level (unconscious) learning* in informal situations such as having dinner. Right: Schematic Illustration of the proposed cognitive system, with Belief Revision corresponding to explicit learning, and Reinforcement Learning corresponding to implicit learning.

## 1.4 Cognitive Systems

Besides the development of technology that serves a practical purpose a main motivation in the field of cognitive systems is to **gain insight into the nature of consciousness** of living beings by computational means, that means by simulations on computers or robotical systems. Cognitive functions such as **reasoning, learning, or perception** are aspects of consciousness that are particularly accessible to a computational approach and simulations can contribute to reveal their nature (“understanding by simulation”). The scientific study of consciousness for a long time concentrated strongly on the *neural* foundations of consciousness alone. Only more recently the view is expanded to the fact that brains are only small parts of larger complex systems, and **interactions of cognitive systems within their environment** are increasingly taken into account. Correspondingly, in the **development of artificial cognitive systems** the first effort was made on the simulation of isolated cognitive functions such as logical reasoning or categorization of stimuli. The idea of investigating **the role of interactions** for the simulation of cognitive abilities appeared only later and is an ongoing field of research. For example, the problem of processing a huge amount of sensory data is reduced enormously, if a system is able to **actively and autonomously select those data from the environment** deemed useful for a task at hand. Another problem is posed by the relationship between **symbolic and subsymbolic cognition**. Humans are able to solve problems by conscious reasoning on the one hand (symbolic cognition), and they perform unaware information processing such as the acquisition of implicit representations of the world on the other hand (subsymbolic cognition). The challenge consists in the way how the gap between symbolic and subsymbolic processing can be bridged, i.e., **how symbolic knowledge on a macro level can emerge from numeric processing on a micro level**. From a technical point of view unsolved problems consist in an appropriate **fusion of numerical and symbolic machine learning methods** and the **fusion of the concept of interaction** with established concepts of machine learning.

## Results

In the reporting period the HCI group could achieve several improvements of its **cognitive architecture**, which is inspired by insights from cognitive psychology and employs the idea of two different forms of human learning, namely **explicit and implicit learning**. It fuses **reinforcement learning** techniques with approaches from the field of **belief revision** - two approaches from quite distinct fields of machine learning. This combination ensures the extension of reasoning capabilities of a high-level learning component with self-organizing capabilities of a low-level learning system, enabling a cognitive agent to learn behavioral rules in an autonomous and self-learning fashion by exploring the environment and while the system is already on duty. Simulations have been carried out, mainly in computer vision applications, as well as a number of theoretical inspections, analyses, and comparisons with state-of-the-art methods in terms of learning speed and plausibility of learned rules. As a consequence, a **faster learning and more plausible results** could be obtained from the proposed hybrid technique than with any of the approaches alone. Several members of the HCI group received invitations to Dagstuhl seminars on "Reinforcement Learning", "Human Activity Recognition in Smart Environments", and "Organic Computing - Design of Self-Organizing Systems". Besides this, the group was active also in the **field of theoretical considerations on complex systems and self-learning systems** in general.

## Publications

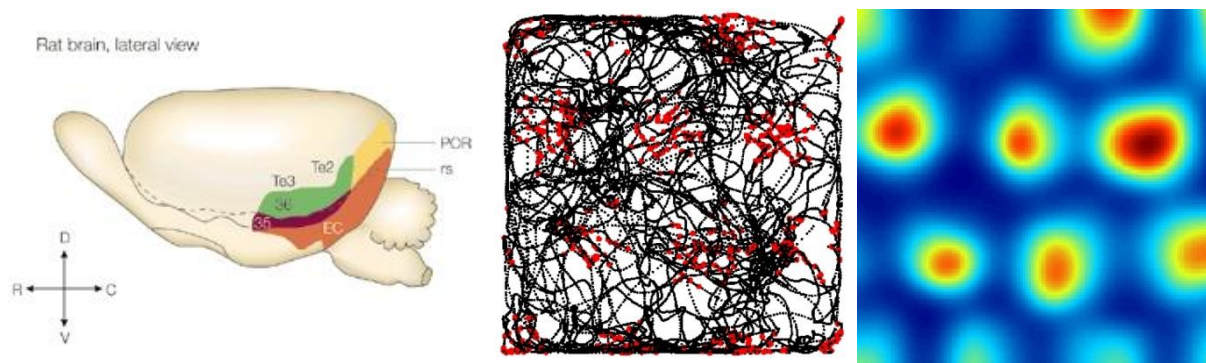
- Klaus Häming and Gabriele Peters, "Towards a Self-Learning Agent: Using Ranking Functions as a Belief Representation in Reinforcement Learning", *Neural Processing Letters*, Vol. 38 (2), pp. 117-129, Springer US, 2013.
- Jochen Kerdels and Gabriele Peters, "Exploratory Modeling of Complex Information Processing Systems", 10th Int. Conference on Informatics in Control, Automation and Robotics (ICINCO 2013), edited by J.-L. Ferrier, O. Y. Gusikhin, K. Madani, and J.Z. Sasiadek, SciTePress, pp. 514-521, Reykjavik, Iceland, July 29-31, 2013.
- Klaus Häming and Gabriele Peters, "Iterated Revisions in Large and Noisy State Spaces Using Ranking Functions", *International Journal of Engineering Intelligent Systems*, edited by L. Iliadis and I. Maglogiannis, Vol. 20 (1/2), 2012.
- Jochen Kerdels and Gabriele Peters, "A Generalized Computational Model for Modeling and Simulation of Complex Systems", Research Report 4/2012, number 2889, Research Reports FernUniversität in Hagen, Department of Mathematics and Computer Science, Hagen, Germany, Dezember 2012.
- Klaus Häming and Gabriele Peters, "Making a Reinforcement Learning Agent Belief", 22nd International Conference on Artificial Neural Networks (ICANN 2012), edited by A. E. P. Villa, W. Duch, P. Erdi, F. Masulli, and G. Palm, LNCS 7552, Springer, pp. 435-442, Lausanne, Switzerland, September 11-14, 2012.



- Gabriele Peters, "Six Necessary Qualities of Self-Learning Systems - A Short Brainstorming", Proc. of the International Conference on Neural Computation Theory and Applications (NCTA 2011), pp. 358-364, Paris, France, October 24-26, 2011.
- Klaus Häming and Gabriele Peters, "Improved Revision of Ranking Functions for the Generalization of Belief in the Context of Unobserved Variables", Proceedings of the International Conference on Neural Computation Theory and Applications (NCTA 2011), pp. 118-123, Paris, France, October 24-26, 2011.
- Klaus Häming and Gabriele Peters, "Ranking Functions in Large State Spaces", 7th International Conference on Artificial Intelligence Applications and Innovations (AIAI 2011), Corfu, Greece, September 15-18, 2011.
- Klaus Häming and Gabriele Peters, "An Alternative Approach to the Revision of Ordinal Conditional Functions in the Context of Multi-Valued Logic", 20th International Conference on Artificial Neural Networks (ICANN 2010), edited by K. Diamantaras, W. Duch, and L. S. Iliadis, LNCS 6353, Springer, pp. 200-203, Thessaloniki, Greece, September 15-18, 2010.

### Talks and Presentations

- Jochen Kerdels, "Exploratory Modeling of Complex Information Processing Systems", poster presentation, ICINCO 2013, Reykjavik, Iceland, July 29, 2013.
- Jochen Kerdels, "A Generalized Computational Model for Modeling and Simulation of Complex Systems", talk, Dagstuhl-Seminar 12492 "Human Activity Recognition in Smart Environments", Schloss Dagstuhl – Leibniz Center for Informatics, Germany, December 04, 2012.
- Klaus Häming, "Making a Reinforcement Learning Agent Believe", talk, ICANN 2012, Lausanne, Switzerland, September 11, 2012.
- Klaus Häming, "Six Necessary Qualities of Self-Learning Systems - A Short Brainstorming", poster presentation, NCTA 2011, Paris, France, October 24, 2011.
- Klaus Häming, "Improved Revision of Ranking Functions for the Generalization of Belief in the Context of Unobserved Variables", talk, NCTA 2011, Paris, France, October 24, 2011.
- Klaus Häming, "Ranking Functions in Large State Spaces", talk, AIAI 2011, Corfu, Greece, September 15, 2011.
- Gabriele Peters, "A proposal how to combine bottom-up emergence and top-down control during runtime", talk, Dagstuhl-Seminar 11181 "Organic Computing - Design of Self-Organizing Systems", Schloss Dagstuhl – Leibniz Center for Informatics, Germany, May 03, 2011.
- Klaus Häming, "An Alternative Approach to the Revision of Ordinal Conditional Functions in the Context of Multi-Valued Logic", talk, ICANN 2010, Thessaloniki, Greece, September 15, 2010.



**Computational Model of Grid Cells.** Left: Lateral view of a rat brain showing the entorhinal cortex (EC) which contains grid cells. Image from Brown & Aggleton, "Recognition memory: What are the roles of the perirhinal cortex and hippocampus?", *Nature Reviews Neuroscience*, 2001. Middle: Black lines depict a real path of a rat foraging 10 minutes in a 1m x 1m box, with superimposed spike locations of one simulated grid cell (red dots). Path data provided by Sargolini et al., 2006. Right: Firing rate map obtained from a grid cell simulated by the HCI group using the real path data (blue: low values, red: high values).

## 1.5 Computational Neuroscience

The field of Computational Neuroscience is related and closely connected to Cognitive Systems, one of the other core area of research of the HCI group. But whereas one goal of the field of Cognitive Systems can consist in the development of technical applications, Computational Neuroscience primarily undertakes **basic research** with the only goal of gaining insight into the nature of consciousness, or more concrete, into the nature of brain functions and information processing in biological systems. Computational Neuroscience is engaged in the **development of computational models** that cover features of **nervous systems** essential for cognitive capabilities with the aim of gaining deeper insight into the dynamics and complex interrelations underlying processes of consciousness. Procedural methods of research range from biological or psychological experiments over theoretical approaches up to simulations in computer systems. The **analysis of experimental data** is one major course of action. The subjects of investigation span a range from the low level of chemical processes, over the behavior of single neurons or the dynamics of networks of neurons, up to the higher level of cognitive processes such as **perception, attention, learning, or spatial cognition**. In contrast to the field of Cognitive Systems, **biological realism** of the computational models and the simulations of brain functions are essential, because this constitutes the basis for the derivation of hypotheses on biological information processing, which in turn, can directly be tested in biological or psychological experiments.

## Results

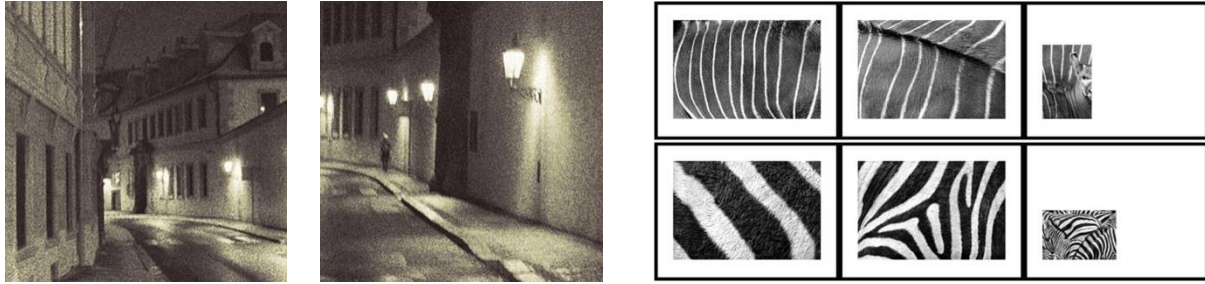
In the reporting period the HCI group has been active in the field of **spatial cognition**, deriving a computational model for specific neurons engaged in spatial cognition of rats. The model was tested in computer simulations on real experimental data and results comparable to the outcomes of those experiments could be obtained, as described in the following. The hippocampal region in the brain of rats, in particular the entorhinal cortex, contains so-called **grid cells** that encode allocentric spatial information. One single grid cell covers the environment of the animal with a virtual, triangular lattice and fires whenever the animal passes through a vertex of this lattice. A number of computational models already exist, that try to explain the formation of grid-like firing fields. Although those existing models can explain the experimental findings quite well, they make more or less extensive assumptions on specific cell or network properties. The HCI group **developed a computational model for grid cells** that can explain the observed properties of grid cells with fewer and less specific assumptions. This model comprises three interacting processes and is based on the idea that the dendritic tree of a grid cell can be regarded as sparse self-organizing map. The model was tested in experiments **using real movement data of a rat** and proved to be capable of recreating the distinctive, triangular firing pattern observed in real grid cells. The movement data have been provided by the research group of May-Britt and Edvard Moser (Norwegian University of Science and Technology, Trondheim), who received the *Nobel Prize in Physiology or Medicine 2014* for the discovery of grid cells. One of the group's doctoral research assistants was **nominated for the best paper award** at the *International Conference on Neural Computation Theory and Applications 2013* for his contributions to this project (see section 2.3).

## Publications

- Jochen Kerdels and Gabriele Peters, "A Computational Model of Grid Cells based on Dendritic Self-Organized Learning", International Conference on Neural Computation Theory and Applications (NCTA 2013), SciTePress, pp. 420-429, Vilamoura, Portugal, September 20-22, 2013.

## Talks and Presentations

- Jochen Kerdels, "A Computational Model of Grid Cells based on Dendritic Self-Organized Learning", talk, NCTA 2013, Vilamoura, Portugal, September 20, 2013.



**New Media Art and Analysis of Image Aesthetics.** Left: Two of four art works invited for a group exhibition at Brunei Gallery, Museum Mile, London, in 2011. Right: Excerpt from a survey on aesthetics for computer scientists, visualizing the aesthetic principle of rhythm by a repetition of patterns.

## 1.6 New Media Art

New Media Art spans a wide range of different art forms. In a broad sense it designates art produced by means of a computer. In a more concrete sense it means **art forms that are made at all possible by digital techniques** in the first place, such as interactions with autonomous, artificial systems, virtual reality applications, or the utilization of now available, massive amounts of data for artistic purposes. In this field of interest the HCI group is active in three different directions. First, the group inspires and provides **techniques for artistic expression**, for example, with the aid of computer vision methods. In this sense, the other core areas of research provide tool boxes for the creation of art works. Second, the group is engaged in gaining insights from the arts, design theory, or aesthetics for **fostering a better design of interfaces** of interactive systems. This is reflected in considerations of theoretical aspects and their implications for interface design, as well as **analytical examinations of existing works**. And third, the HCI group also **creates ordinary art**, mostly in the field of photography. Artistic topics are situated around irritation and alienation of reality, as well as human isolation in urban environments.

### Results

In the reporting period a number of visual art works have been created using a developed **hybrid photographic technique**, which have been invited for display at **several exhibitions**, online and physically. The technical process to generate these kinds of images combines analog and digital techniques. At the bottom and besides further steps of processing, photographs are taken on panchromatic film, small sections of the negatives are scanned with high resolution, and artificial grain is added to further exaggerate the effect of the film grain, causing an intended pointillist effect. Furthermore, the HCI group **analyzed the aesthetic value of images on websites of museums**, among them *Tate*, London, and *Deutsches Museum*, Munich, and summarized the results in a **survey article for software developers on the creation of aesthetic images for the use in interfaces**.

## Publications

- Gabriele Peters, "Night Walk II", 13<sup>th</sup> International Symposium on Digital Art and Gallery (D-ART 2013), 10<sup>th</sup> International Conference on Computer Graphics, Imaging and Visualization (CGIV 13), Macau, China, August 6-8, 2013.
- Gabriele Peters, "Night Walk", 12<sup>th</sup> International Symposium on Digital Art and Gallery (D-ART 2012), 9<sup>th</sup> International Conference on Computer Graphics, Imaging and Visualization (CGIV 12), Hsinchu, Taiwan, July 24-27, 2012.
- Gabriele Peters, "Criteria for the Creation of Aesthetic Images for Human-Computer Interfaces - A Survey for Computer Scientists", International Journal of Creative Interfaces and Computer Graphics, Vol. 2 (1), pp. 68-98, 2011.
- Gabriele Peters, "Dark Days - Prague II", 11<sup>th</sup> International Symposium on Digital Art and Gallery (D-ART 2011), 8<sup>th</sup> International Conference on Computer Graphics, Imaging and Visualization (CGIV 11), Singapore, August 16-19, 2011.
- Gabriele Peters, "Dark Days - Venice - Hybrid Photographic Techniques", 10<sup>th</sup> International Symposium on Digital Art and Gallery (D-ART 2010), 7<sup>th</sup> International Conference on Computer Graphics, Imaging and Visualization (CGIV 10), Sydney, Australia, August 7-10, 2010.

## Exhibitions

- Gabriele Peters, "Night Walk II", Online Exhibition at 13<sup>th</sup> International Symposium on Digital Art (D-ART 2013), 17<sup>th</sup> International Conference Information Visualisation (iV 2013), London, UK, July 15-18, 2013.
- Gabriele Peters, "Night Walk", Online Exhibition at 12<sup>th</sup> International Symposium on Digital Art (D-ART 2012), 16<sup>th</sup> International Conference Information Visualisation (iV 2012), Montpellier, France, July 10-13, 2012.
- Gabriele Peters, "Dark Days - Prague II", Online Exhibition and Physical Exhibition at 11<sup>th</sup> International Symposium on Digital Art (D-ART 2011), 15<sup>th</sup> International Conference Information Visualisation (iV 2011), London, UK, July 12-15, 2011.
- Gabriele Peters, "Dark Days - Venice - Hybrid Photographic Techniques", Online Exhibition at 10<sup>th</sup> International Symposium on Digital Art (D-ART 2010), 14<sup>th</sup> International Conference on Information Visualisation (iV 2010), London, UK, July 26-29, 2010.





**Academic Mentoring.** Left: Girls' Day 2012 with research assistant Klaus Häming explaining the robot arm to one of a group of visiting scholars. Right: Award ceremony at *Informatiktage 2012* with student assistant Sergey Cheremukhin (second from right, see section 2.2).

## 2 Academic Mentoring of Young Scientists

The mentoring, promotion, and support of the next generation of scientists is a major concern of the Chair of Human-Computer Interaction. In order to attract prospective academics for a scientific career the HCI group is active on several levels, starting at the early age group of scholars, through the encouragement of students and scientific junior staff, up to the mentoring and promotion of research assistants in their doctoral as well as post-doctoral career stages.

### 2.1 Scholars

On a regular basis the HCI group participates in the annual Girls' Days by presenting current research results to female scholars. With talks and demonstrations in the interaction lab in Hagen the group is engaged in drawing their interest to the fascinating topics of interactive and intelligent systems.

#### Talks and Demonstrations in the Course of Girls' Days

- Jens Garstka, "3D-Fotografie und ein TicTacToe-spielender Roboter", talk and demonstrations, Girls' Day 2013, Interaction Lab, FernUniversität in Hagen, April 24, 2013.
- Klaus Häming, "3D-Rekonstruktion und ein spielender Roboter", talk and demonstrations, Girls' Day 2012, Interaction Lab, FernUniversität in Hagen, April 26, 2012.
- Klaus Häming, "3D-Rekonstruktion", talk and demonstrations, Girls' Day 2011, Interaction Lab, FernUniversität in Hagen, April 14, 2011.



## 2.2 Students

The HCI group integrates motivated students in current research projects, attracts their attention to announcements of contests, and supports them in submitting their works such as their theses results to student competitions. In the reporting period two of the group's students, Sergey Cheremukhin and Christoph Drexler, have been invited to give talks about their works at the *Informatiktage 2012* und *2013* in Bonn. Both works have been **nominated for the best submitted work** beforehand, and Sergey Cheremukhin received the **3<sup>rd</sup> award for the best paper**.

### Awards and Nominations to Students

- **Nomination for Best Paper Award:** Christoph Drexler, "Abschätzung des Disparitäts-raumes für das Stereo-Matching mithilfe von Bildmerkmalen", *Informatiktage 2013, Lecture Notes in Informatics, Vol. S-12*, pp. 205-208, Gesellschaft für Informatik, Bonn, Germany, March 22-23, 2013.
- **3rd Award for Best Paper:** Sergey Cheremukhin, "Vereinfachte 3D-Rekonstruktion aus Sequenzen unkalibrierter Bilder", *Informatiktage 2012, Lecture Notes in Informatics, Vol. S-11*, pp. 183-186, Gesellschaft für Informatik, Bonn, Germany, March 23-24, 2012.

## 2.3 Doctoral Research Assistants

Research assistants at the HCI group are encouraged to submit their results directly to renowned, international journals, workshops, or conferences, where in the reporting period one of the group's doctoral research assistants, Jochen Kerdels, was successful in receiving a nomination for the best paper award. Furthermore, two doctoral candidates received invitations to seminars at the Leibniz Center for Informatics Schloss Dagstuhl, the world's premier venue for informatics. Furthermore, in the reporting period Klaus Häming finished his doctoral thesis, entitled "Reinforcement Learning in a 3D-Environment Applied to View-based Object Recognition". He presented several results of his thesis at numerous international conferences and workshops before and was awarded the degree Doctor of Natural Sciences (Dr. rer. nat.) by the Faculty of Mathematics and Computer Science of the FernUniversität in 2011.

All doctoral candidates of the HCI group participate on a regular basis in doctoral seminars promoted by the FernUniversität in an interdisciplinary setting together with doctoral candidates of other chairs and faculties of the university.



### Nominations to Research Assistants

- **Nomination for Best Paper Award:** Jochen Kerdels and Gabriele Peters, "A Computational Model of Grid Cells based on Dendritic Self-Organized Learning", International Conference on Neural Computation Theory and Applications (NCTA 2013), SciTePress, pp. 420-429, Vilamoura, Portugal, September 20-22, 2013.

### Talks of Research Assistants in the Course of Doctoral Seminars

- Jens Garstka, "Learning Strategies to Select Point Cloud Descriptors for 3D Object Classification", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, February 18, 2014.
- Jochen Kerdels, "Exploratory Modeling of Complex Information Processing Systems", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, February 18, 2014.
- Jens Garstka, "Reinforcement Learning-gestützte Klassifikation von 3D-Punktwolken", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, July 19, 2013.
- Jochen Kerdels, "A Computational Model of Grid Cells based on Dendritic Self-Organized Learning", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, July 19, 2013.
- Jens Garstka, "Hierarchical Reconstruction From Image Pairs: Simulations and Benchmarking", doctoral seminar at the Leibniz Center for Informatics Schloss Dagstuhl, organized by L. Mönch, March 6, 2013.
- Jochen Kerdels, "A Conjoint Computational Model for Modeling and Simulation of Complex Systems", doctoral seminar at the Leibniz Center for Informatics Schloss Dagstuhl, organized by L. Mönch, March 6, 2013.
- Jens Garstka, "Hierarchical Reconstruction From Image Pairs: Simulations and Benchmarking", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, February 13, 2013.
- Jochen Kerdels, "A Conjoint Computational Model for Modeling and Simulation of Complex Systems", doctoral seminar at FernUniversität in Hagen, organized by M. Hemmje, February 13, 2013.

### Finished Doctoral Dissertations

- Dr. rer. nat. Klaus Häming: doctoral thesis entitled "Reinforcement Learning in a 3D-Environment Applied to View-based Object Recognition", date of disputation: February 24, 2011.





Knowledge Transfer in the Form of Reports in Mass Media and Open Source Software.

### 3 Knowledge Transfer

Knowledge transfer means the transfer of research achievements to society. Besides the probably most sustainable way to disseminate research results by direct teaching of students and young researchers, powerful means consist in the launching of reports through the mass media, which are consumed by a non-scientific target group, as well as the publication of research results on the internet. Especially in the field of computer science, where patents are no possibility, the publication of open source software constitutes another way of providing society with results of research efforts. In contrast to knowledge transfer via cooperation's with companies or the foundations of spin-offs, where only a few profit from obtained knowledge, the mentioned ways of dissemination have the advantage that they, on the one hand, can give orientation for a non-scientific audience, and on the other hand, give back to the public what belongs to the public in case the research projects have been made possible by public funding. As the Chair of Human-Computer Interaction is funded exclusively by the public, research results are disseminated by providing information on achievements via the **internet** and the **mass media**, as well as the publication of **open source software**.

#### 3.1 Press Review

In the reporting period the following reports on the HCI group's work and other activities have been published in public media and media of the FernUniversität.

##### The HCI Group in Public Media

- *3D-Modelle schneller berechnen*, FKT, Fachzeitschrift für Fernsehen, Film und elektronische Medien, issue 06/2013
- *Masterarbeit an der FernUniversität: 3-D-Modelle schneller berechnen*, www.lifepr.de, United News Network, 19.06.2013
- *Masterarbeit an der FernUniversität: 3-D-Modelle schneller berechnen*, www.unicheck.de, 19.06.2013

- *Masterarbeit an der FernUniversität: 3-D-Modelle schneller berechnen*,  
www.uni-protokolle.de, 19.06.2013
- *Masterarbeit an der FernUniversität - 3-D-Modelle schneller berechnen*,  
www.profifoto.de, 19.06.2013
- *Masterarbeit an der FernUniversität: 3-D-Modelle schneller berechnen*,  
www.juraforum.de, 19.06.2013
- *Dreidimensionale Bilder schneller berechnen*,  
www.Finzen100.de, 19.06.2013
- *„Mädels, verzichtet nicht auf euer Potenzial!“*,  
life + science, Heft 3, September 2012
- *Einfacher zu 3D-Bildern*,  
PROFIFOTO, Magazin für professionelle Fotografie, issue 5/2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
www.photonik.de, 15.05.2012
- *GI-Wettbewerb Informatiktage 2012: Perspektiven für Studierende*,  
iX magazin, 26.04.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen - Einfacher und schneller zu 3D-Bildern*,  
www.photonicnet.de, News April 2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
Photonik, Fachzeitschrift für die Optischen Technologien, issue 3/2012
- *Einfacher und schneller zu 3D-Bildern - Mitarbeiter der FernUniversität Hagen  
nominiert*,  
www.digitalfotografie.de, 23.03.2012
- *Mitarbeiter der FernUniversität Hagen nominiert*,  
www.profifoto.de, 23.03.2012
- *Einfacher und schneller zu 3D-Bildern*,  
VISUELL aktuell, 23.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
AV-LIVE Online-Fachzeitschrift für Fernsehschaffende, Produktionshäuser,  
Medienleute & Event-Technik, 22.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
www.vdc-fellbach.de, Virtual Dimension Center Fellbach, Kompetenzzentrum für vir-  
tuelle Realität und Kooperatives Engineering w.V., 22.03.2012
- *3D-Bilder mit zwei Fotos möglich*,  
www.koelncampus.com, 22.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen: Einfacher und schneller zu 3D-Bildern*,  
Freiheitliche Zeitung, 21.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
www.kompetenznetze.de, Bundesministerium für Wirtschaft und Technologie,  
21.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen: Einfacher und schneller zu 3D-Bildern*,  
www.juraforum.de, 21.03.2012

- *Eine Kamera, zwei Fotos, drei Dimensionen: Einfacher und schneller zu 3D-Bildern*,  
www.extremnews.com, 21.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
www.Finzen100.de, 21.03.2012
- *Einfacher und schneller zu 3D-Bildern*,  
Digitale Fotografie, 20.03.2012

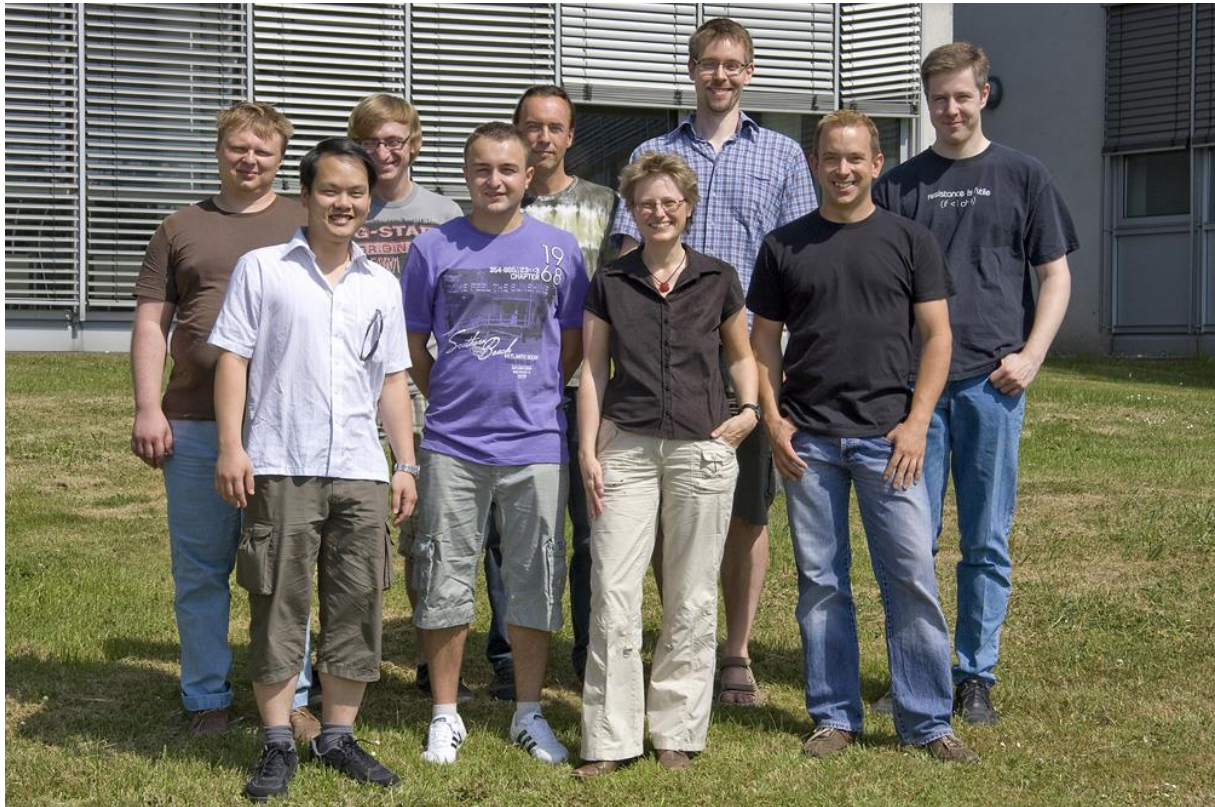
### The HCI Group in FernUniversität's Media and Press Releases

- *Masterarbeit – Schneller zu 3-D-Modellen*,  
FernUni Perspektive, issue 44, summer 2013
- *Masterarbeit an der FernUniversität: 3-D-Modelle schneller berechnen*,  
press release on idw – Informationsdienst Wissenschaft, 19.06.2013
- *Eine Kamera, zwei Fotos, drei Dimensionen*,  
Jahrbuch 2012 of the FernUniversität in Hagen, 2012
- *„Ausgezeichneter“ Mitarbeiter – Leichter 3D-Bilder erzeugen*,  
FernUni Perspektive, issue 40, summer 2012
- *Girls' und Boys' Day – Spannender Projekttag*,  
FernUni Perspektive, issue 40, summer 2012
- *Eine Kamera, zwei Fotos, drei Dimensionen: Einfacher und schneller zu 3D-Bildern*,  
www.twitter.com/#!/idw\_online\_de/statuses/182449048018616320, Tweet,  
21.03.2012
- *Eine Kamera, zwei Fotos, drei Dimensionen: Einfacher und schneller zu 3D-Bildern*,  
press release on idw – Informationsdienst Wissenschaft, 21.03.2012
- *Girls' Day 2011 - „Später mach' ich was mit Informatik“*,  
FernUni Perspektive, issue 36, summer 2011
- *Antrittsvorlesung von Prof. Gabriele Peters - Vom Menschen zum Computer und zurück*,  
FernUni Perspektive, issue 35, spring 2011
- *Fünf Fragen an: Gabriele Peters (Audio-Podcast)*,  
YouTube channel of the FernUniversität in Hagen, 13.01.2011
- *Fünf Fragen an: Gabriele Peters (Audio-Podcast)*,  
www.facebook.com, 13.01.2011

## 3.2 Open Source Software

In the reporting period the **freehand acquisition software** described in section 1.1 was published under a Creative Commons license, which precludes commercial application, and is publicly available from [www.fernuni-hagen.de/mci/resources/](http://www.fernuni-hagen.de/mci/resources/).





**Human-Computer Interaction Group at FernUniversität in Hagen.** From left to right: Sergey Cheremukhin, Nico Sudyartma, Paul Kornev, Georgiy Mühlig, Christoph Doppelbauer, Gabriele Peters, Klaus Häming, Jens Garstka, Jochen KerdeIs . Photo: Jens Garstka.

## 4 Facts and Numbers

### 4.1 Funding

In the reporting period non-commercial funding in the total amount of **TEUR 200** was available for the Chair of Human-Computer Interaction, including a research grant in the amount of **TEUR 80** received from the **Deutsche Forschungsgemeinschaft** (project Pe 887/3-3, „Dynamisches Lernen zur geometrischen und graphischen Objekterfassung“, 04/2010 - 03/2011).

### 4.2 Members

In the reporting period following persons were affiliated with the Chair of Human-Computer Interaction:

### Chair

- Prof. Dr. rer. nat. Gabriele Peters

### Secretary

- Nicole Wrobel

### Technical Assistant

- Christoph Doppelbauer

### Post-Doctoral Research Assistant

- Dr. rer. nat. Klaus Häming (as of February 24, 2011)

### Doctoral Research Assistants

- Jens Garstka
- Klaus Häming (until February 23, 2011)
- Jochen Kerdels

### Student Assistants

- Sergey Cheremukhin
- Jens-Christian Dobbert
- Barbara Fast
- Paul Kornev
- Georgiy Mühlig
- Nico Sudyatma
- Dennis Urban

### External Doctoral Candidate

- Nils Kurowsky