Staff

- Associate Professor:
  Univ.-Prof. Gerhard Lakemeyer, Ph. D.
e-mail: lakemeyer@informatik.rwth-aachen.de
www: http://kbsg.rwth-aachen.de/

- Secretaries:
  Gabriele Hoeppermanns
  Phone: +49 241 80 21501
  Fax: +49 241 80 22321
e-mail: sekris@i5.informatik.rwth-aachen.de

- Research Assistants:
  Dipl.-Inform. Daniel Beck
  Ms.Sc. Vaishak Belle
  (funded by DFG)
  Dipl.-Inform. Jens Claßen
  (funded by DFG)
  Dipl.-Inform. Stefan Schiffer
  (funded by DFG)

- Student Researchers:
  Masrur Doostdar, Bahram Maleki-Fard,
  Tim Niemüller, Christoph Schwering,
  Niklas Hoppe
Staff (contd.)

- Visiting Researchers:

  Thomas Meyer, Ph. D., Meraka Institute, South Africa
  (August 2010)

  Prof. Hector Levesque, Ph. D., University of Toronto, Canada
  (September – December 2010)

  Radhakrishnan Delhibabu, Anna University
  (September 2010 – July 2011)
Overview

A major focus of our group is *Cognitive Robotics*. Research in Cognitive Robotics is concerned with the theory and the implementation of robots that reason, act and perceive in changing, incompletely known, unpredictable environments. Such robots must have higher level cognitive functions that involve reasoning, for example, about goals, actions, when to perceive and what to look for, the cognitive states of other agents, time, collaborative task execution, etc. In short, Cognitive Robotics addresses the integration of reasoning, perception and action within a uniform theoretical and implementation framework.

As part of our own research in Cognitive Robotics we are concerned with the development of logic-based languages suitable for the high-level control of mobile robots, and their embedding into robotic systems. On the one hand, such languages allow the description of robotic tasks at an abstract level in terms of high-level actions and their effects on the state of the world. On the other hand, by interpreting these languages, the robots are able to reason about their own goals, the actions they have at their disposal and the way the world changes as a result of these actions. The languages we are considering are extensions of Golog, whose semantics is based on the situation calculus and which was originally developed by Ray Reiter and his colleagues at the University of Toronto. We are investigating extensions regarding actions which change the world continuously and actions with probabilistic outcome. In a recent project funded by the German Science Foundation (DFG) and in collaboration with the University of Freiburg, we are investigating the integration of Golog with state-of-the-art planning systems. In another DFG-funded project, we are applying our techniques to the control of robots in highly dynamic domains like robotic soccer and, more recently, in home-robot scenarios, where the interaction with humans plays an increasing role. In this context, we are also working on methods for sound-source localization, in collaboration with Prof. Wagner from Biology and funded by DFG. Last but not least we are also actively engaged in designing and building robots, together with the necessary low-level control software.
Research Projects

A Deliberative Real-Time Component for Cooperating Multi-Robot Systems in Highly Dynamic Environments (RoboCup) (SPP 1125)

Alexander Ferrein, Gerhard Lakemeyer

The goal of this project is to develop a deliberative component supporting coordinated actions of multi-robot systems under real-time constraints, using robotic soccer as a benchmark application. This project is part of the research initiative “RoboCup” (SPP 1125) funded by the German Science Foundation. The basis for the deliberative component to be developed in this project is the logic-based action language Golog, which was initially conceived at the University of Toronto. Golog has been extended within our group in recent years and applied successfully to the control of mobile robots in office environments and museums.

In this project, a dialect of Golog featuring models of continuous change and uncertainty will be suitably adapted and integrated into a system, which combines both the reactive and deliberative choice of actions. Moreover, for the action selection process a decision-theoretic planning approach based on Markov Decision Processes is used. With this kind of planning integrated into the Golog framework the robot is able to choose an optimal course of actions with respect to a suitable utility function. Additionally, this framework allows for taking into account the uncertainties arising in the domain, e.g. a pass to a teammate may succeed or fail with a certain probability.

To validate our approach in the framework of RoboCup, we apply it to both the simulation league and real robots in the so-called Middle Size League, using our soccer robots which we built in 2002 with a grant of the NRW Ministry of Education and Research and in collaboration with the Department of Electrical Engineering (Prof. Kraiss).

Moreover, we evaluated our approach not only in the soccer domain, but also showed its usefulness for the encoding of computer players (so-called game bots) in interactive computer games like UNREAL Tournament 2004.

Cognitive Service Robotic Systems and Applications

Stefan Schiffer, Gerhard Lakemeyer

The research areas of the Knowledge-Based Systems Group are Knowledge Representation, Reasoning, and as an application Cognitive Robotics. One of our aims
is to develop intelligent mobile robot platforms. With a funding from the German National Science Foundation (DFG) in the Priority Program “Cooperative multi-robot teams in highly dynamic domains” and the Ministry for Science of North-Rhine Westphalia, Germany (MSWF) we developed five robots and participate in RoboCup Championships with these robots for several years now. RoboCup is an international research initiative to foster research and education in the field of artificial intelligence and robotics. The common problem is to develop autonomous soccer playing robots (www.robocup.org).

The scope of the RoboCup initiative has gotten much broader in recent years. It now also covers the design of robots to rescue people from urban disaster areas in the RoboCup Rescue leagues or the development of service robots in the RoboCup@Home league. The task of robots in the latter domain is to help people in a home-like environment with fulfilling tasks of everyday life.

The “AllemaniACs” RoboCup Team participated in the soccer competitions with the initial robot platform for several years. Since the platform initially developed for soccer was designed with also other applications in mind from the beginning, we could easily enter the service robotic competition. We participate in the RoboCup@Home league since the first competition in 2006.

To be successful in RoboCup@Home we adapted our robot system. The basic components of the robot system were designed in such a way that they could be used in the new scenario without substantial modifications. It was our laser-based localization following a Monte Carlo approach and a very robust collision avoidance and navigation module that provided us with a stable basis to move from the soccer field to the home-
like environment. In fact, both these modules work even better in more structured environments and with lower speeds than in the soccer domain. A map building tool which allows for semantic annotations of maps used for localization and navigation was developed. The annotations are available throughout the whole system and especially for the human machine interface. By adapting our ball recognition to other shapes and colors we were also able to detect other objects in the home environment.

Important tasks in the @Home domain are to localize oneself in the home environment, not to collide with anything in the apartment, and to interact with humans living in it (human-machine interaction). The annual tournament is structured in several specific tasks called tests, that each check for one or more important abilities of the robot. In a so-called Open Challenge and in the Final teams can freely demonstrate whatever they think is their robot’s most noteworthy functionality.

In the last three years we continuously enhanced our robot’s abilities both in soft- and in hardware. We installed a six degree of freedom manipulator and a stereo camera to better perceive and to manipulate things in the environment (cf. Fig. 1). The control software now features a generic object detection and recognition module, robust and flexible speech recognition used to command the robot, and further a new approach to face detection, recognition, and learning which is indispensable for any human-robot interactive application. After winning the world championship in 2006 and 2007 we became vice world champion in the 2008 competition in Suzhou, China. Furthermore, we won the RoboCup German Open in 2007 and in 2008.

In 2009, we started over by moving large parts of our control software to our newly developed robot control software fawkes. Furthermore, we were the first team in the competition to show robot-robot communication and coordination when we made two of our robots team up to serve multiple guests in a party-like scenario. We were also actively involved in research on how service robots can be benchmarked and what results from benchmarking activities such as RoboCup@Home have been obtained so far. In 2010, we took a break from the competitions to elicit possible further extensions of our robotic system and to consolidate the existing features. For one, we extended our research in making use of fuzzy representations and control in a domestic setting. For another, we worked towards integrating self-maintenance into the robotic system. That is to say, we studied ways to enable the robot to autonomously take care of issues coming up at run-time that would normally lead to a failure.

RoboCup Middle Size League Soccer Robots
Daniel Beck, Alexander Ferrein, Gerhard Lakemeyer

Contrary to other RoboCup soccer leagues the robots in the Middle Size League are completely autonomous and self-contained which means that they carry all the nec-
Figure 2: The pictures above show a CAD model of the robot and its real counterpart in a late prototype stadium. Clearly visible are the omni-directional wheels, the newly developed kick mechanism, the omni-vision camera on top of the robot, and the stereo camera mounted below.

necessary sensors and computational devices on-board. Recent changes in the rules for the Middles Size League and the overall progress in the league made it difficult to compete with a general purpose robotic platform as we did since 2002 (cf. Fig. 1). The most prominent changes are the increase of the field size which is 18 x 12 m, now, and the removal of any colored markings on the field which makes the two halves now identical.

Thanks to a grant of the Bonn-Aachen Institute of Technology and the support from the Chair of Computer Science 5 we were able to develop a new, specialized robot platform for the RoboCup soccer competitions. In the design of the new robots we followed the de-facto standard in the league by integrating an omni-directional drive system and an omni-vision camera system. Such an omni-directional drive system allows the robot to move into arbitrary directions without any constraints. The omni-vision camera system consists of a hyperbolic mirror that is mounted atop of a camera at the top of the robot (cf. Fig. 2). The images obtained from the camera depict the complete surroundings of the robot. Additionally, the robots are equipped with a stereo-camera which delivers a three-dimensional re-construction of the objects in front of the robot. The construction and manufacturing of the robots was accomplished in collaboration with the chair for Engineering Design led by Prof. Dr.-Ing. Jörg Feldhusen.

With the support of Festo Didactic GmbH we developed a new multi-actuator kick system for the robots. It is driven by two pneumatic muscles and a pneumatic cylinder which can be triggered individually. Such a kick system allows to vary the intensity
with which the ball is kicked over a large range. This leads to more possibilities to pass the ball to a team-mate and will hopefully enhance the passing game between the robots.

For the new robots we developed a new framework for the robot control software, named *Fawkes*. Major design goals were low latencies, support for multi-core CPUs, clearly structured flow of data, good scaling properties and a high degree of portability. The success of the last two goals is made clear by the fact that the control software for our soccer robots as well as for the humanoid Nao robots is developed on basis of the same framework.

Since the new platform strongly deviates from the old one certain key modules of the control software had to be adapted or newly developed, respectively. The new drive system required to implement new motion and navigation modules. Since the new robots are not equipped with a laser-range finder (LRF) as the old ones we needed a new localization module that solemnly works on visual information retrieved from the omni-vision camera.

---

**HeRBiE: Hearing on a robot, binaurally enhanced**

_Laurent Calmes, Gerhard Lakemeyer, Hermann Wagner (Biologie II)_

The aim of this work is to equip a mobile robot with a method of sound source localization by using biologically inspired algorithms. The Jeffress model has been a fruitful scheme for understanding the representation of inter-aural time difference as an azimuthal sound-localization cue. As an improvement over previous work, we used the complete three-dimensional coincidence map for determining the azimuth of a sound source. A first implementation of the algorithm on the mobile robot Carl has been completed with promising results. Localization of broadband sound sources could be achieved with excellent precision. Localization of low frequency, narrowband signals is less than satisfactory. This was initially ascribed to the acoustical characteristics of the microphone mount. With the help of acoustic room simulations conducted in 2006, we could show that the inferior performance for low-frequency, narrowband signals is not caused by the microphone mount and neither by the algorithm, but by room reverberations. We integrated a sound localizer based on inter-aural level differences as well as an attention module with the current system. Furthermore, a beamformer module was developed which allows spatial filtering, i.e., sounds coming from a given direction can be enhanced while all other directions are attenuated. A first attempt was made at combining laser-based object recognition and sound localization on one of the RoboCup robots. We are currently working on more sophisticated methods for exploiting these two sensor modalities. Specifically, a Markov Chain Monte Carlo-based tracking algorithm is in the process of being implemented, which will make it possible for the robot to track dynamic objects emitting sounds (e.g. humans) over
time. In combination with the beamformer, this system can act as a front end for speech recognition, by enhancing speech signals from the direction of a human, on which the robot’s attention is focused.

PLATAS – Planning Techniques and Action Languages

Jens Claßen, Gerhard Lakemeyer, Bernhard Nebel*, Gabriele Roeger*

* (University of Freiburg)

Although there is a common origin, research on automated planning on the one hand and action logics on the other hand developed rather independently over the last three decades. This is mainly due to the fact that work on action languages was concerned with formalisms of high expressiveness, whereas for planning methods, the focus had to lie on computational efficiency, yielding input languages with less expressive possibilities. However, one can observe that during the last few years, the two separate fields began to converge again. Exemplary for this trend is the development of the planning domain definition language PDDL, which extends simple STRIPS-based planning by features such as conditional effects, time, concurrency, axioms, and plan constraints and preferences, and which virtually constitutes a standard in the field of planning.

This soon to be completed, DFG-funded project started in 2005 and has been conducted in cooperation with the Research Group on the Foundations of Artificial Intelligence lead by Bernhard Nebel at the University of Freiburg. It aims at integrating latest results in the areas of both action languages (in particular, GOLOG) and planning techniques (in particular, PDDL-based planners like Hoffmann and Nebel’s FF) to acquire systems that are both expressive and efficient. In the first project phase we have worked on establishing a common semantic basis for both GOLOG and PDDL within the situation calculus. This has been achieved first for the ADL fragment of PDDL, and was subsequently extended by the language’s further features. The situation calculus semantics for PDDL now covers roughly the full scope of PDDL, thus providing the foundation for embedding state-of-the-art planning systems like FF in Golog. Expressiveness was further studied formally by means of compilation schemes between corresponding fragments of both formalisms, and experimental evaluations have shown that combining a GOLOG system with a PDDL-based planner is indeed beneficial in terms of savings in the computation time needed by the overall system.

In the second project phase three of the obvious shortcomings and problems that arise even with a GOLOG system with an embedded PDDL planner were tackled. First, available GOLOG systems as well as planners currently lack an efficient and expressive way of representing incomplete world knowledge. For the sake of efficiency, they usually rely on the closed-world and domain closure assumptions, which are not realistic in practice, and constitute a drastic loss of expressiveness. Full first-order logic
on the other hand is unsuitable because of its undecidability. Based on results by Liu, Lakemeyer and Levesque we developed a variant of GOLOG that retains a significant part of first-order expressiveness using so-called proper\textsuperscript{+} knowledge bases, yet allows for a reasoning method that is not only guaranteed to terminate, but, given certain limitations, even tractable. The method relies on a limited form of reasoning that is sound with respect to first-order logic, but only complete for a certain, relevant class of entailments.

Second, the assumption behind PDDL and the associated planning competition is that planners are \textit{domain-independent}. That is, when faced with a new planning problem, it is assumed that such a planner does not possess any prior knowledge about that particular planning domain. While this assumption is justified when it comes to an unbiased comparison of different planning algorithms, it is also well known that in practice, special domain knowledge that is provided by the human domain designer can often help in reducing the search space enormously, and thus speeding up planning significantly. Planners such as TLPlan and TALplanner utilize domain knowledge in the form of formulas in some temporal logic in order to identify branches of the search tree that can be pruned. Furthermore, a GOLOG program by itself already constitutes a form of domain-dependent knowledge in the sense that it is restricts the space of all action sequences to only those adhering to the program, and therefore the domain-independence assumption is untrue in the context of a GOLOG system. For this reason, in order to be able to exploit multiple forms of domain-dependent knowledge together, another objective of this project phase was to embed domain-dependent planners into GOLOG in a similar manner as for the domain-independent ones. To this end, sublanguages of the situation calculus had to be identified that correspond to those planners’ underlying input logics. Within the report period this was achieved for a certain, relevant subset of TALplanner’s Temporal Action Logic, and evaluations showed a significant improvement in the combined system’s runtime behaviour.

Third, before deploying a GOLOG program to an actual agent such as a mobile robot, it is often desirable to verify that it meets certain requirements such as safety, liveness and fairness conditions. While such verification problems have been widely studied in the area of model checking, there has been little research within the situation calculus community, in particular regarding the verification of GOLOG programs that are non-terminating. Non-termination is the typical case in scenarios where the agent performs an open-ended task, such as in the example of an autonomous mobile robot. Simply applying existing model checking techniques here is not appropriate as they work on a single, finite, and complete model of the system, which is not given in the case of a GOLOG agent with incomplete world knowledge, as explained above. To tackle the verification problem for non-terminating GOLOG programs, we designed an extension of the modal situation calculus variant $\mathcal{ES}$ that allows to express programs and their properties in a way that resembles branching time temporal logics, but that includes first-order quantification and where each path quantifier contains a
GOLOG program over whose execution traces the quantification then ranges. Based on this logic we developed an automated verification method that relies on the standard situation-calculus-style reasoning using regression and first-order theorem proving, and that could handle a class of properties resembling the branching time logic CTL (but again includes first-order quantification and GOLOG programs). Recently (ECAI 2010), we extended these results by devising a new algorithm that allows for a more general, CTL*-like class of queries.

Self-Aware Humanoid Robots in the RoboCup Standard Platform League

Alexander Ferrein, Gerhard Lakemeyer

This project is a research co-operation between the University of Cape Town, South Africa, the Technical University Graz, Austria, and the Knowledge-Based Systems Group, and is partly funded by the International Bureau of the BMBF. It aims at developing the control software for a humanoid robot that is not only able to reason about its environment or the next course of actions to take, but also about itself. The robot platform deployed for this project is the Nao platform, manufactured by the French company Aldebaran. The robot is a 58 cm tall biped humanoid robot with 25 degrees of freedom. Figure 3 shows a photo from the Standard Platform League competition at the RoboCup 2009 in Graz. During the last year good progress was made with stabilizing the software framework Fawkes for the robot platform. Fawkes is the deployed control software framework for controlling the low-level system of the Nao platform. It showed its stability during the participation in RoboCup 2009, where our Team Zadeat, which is run by the three project partners, reached a tenth place in the competition. With most of the low-level components running, we started addressing the high-level control. During the report period, a Behaviour Engine based on extended hybrid automata was developed (Niemüller, Ferrein, & Lakemeyer, 2009). The implementation was done in the scripting language Lua which is a interpreted language with a small memory footprint. The Behaviour Engine was designed as a behaviour middle-ware, leaving room for a dedicated high-level control component. This component will be a Golog-based deliberative component which makes use of the underlying behaviour engine. The deliberative component is subject for future work.

Logic-based Learning Agents

Daniel Beck, Gerhard Lakemeyer
The agent programming language GOLOG allows the specification of so-called partial programs. That means the programmer doesn’t have to provide a completely specified program but might leave certain choices on how to proceed with the program open to the agent. The objective, then, is to find an execution trace of the partial program that is legal and optimal wrt. an optimization theory in the current situation.

Contrary to the decision-theoretic planning approach which solves the above problem too, we employ reinforcement learning techniques to learn what the best way of executing a program is by interacting with the environment. This has the advantage that it is not necessary to provide a probabilistic model of the agent’s actions.

The number of training iterations which are necessary before learning shows any beneficial effects highly depends on the number of states the environment can be in. This imposes a severe problem to learning in more complex systems which are made up of huge numbers of different states. Quite often groups of states can be made out whose differences are absolutely irrelevant to the decision that has to be learnt but nevertheless these are handled as separate states. We make use of the basic action theory (BAT) which describes the preconditions and effects of the agent’s actions in order to compute state formulas. Those state formulas are first-order formulas and describe the set of states that are equally good with respect to the remaining program to be executed and the optimization theory.

We have laid out the theoretical foundations for computing those state formulas and integrating the reinforcement learning process into a GOLOG interpreter (Beck & Lake-meyer, 2009). In the future, we intend to adapt our framework to accommodate for more advanced reinforcement learning techniques (e.g., hierarchical reinforcement learning).
Multi-Agent Only-Knowing
Vaishak Belle, Gerhard Lakemeyer

In the area of Knowledge Representation and Reasoning, a fundamental problem is to capture the beliefs of a knowledge-base. For instance, we may want to model that the rules of Poker (every player has 3 cards, the cards are unique, etc.) are all that a game playing agent knows. This would allow the agent to reason that if he has the king of hearts, then an opponent does not, but would not allow the agent to know which precise set of cards an opponent has (at least, not initially).

While beliefs are typically modeled with epistemic logics, it was Levesque, in the early nineties, who proposed the logic of only-knowing where it is possible to say that a set of sentences in a first-order language is precisely all that is known. In this way, he was able to capture both beliefs and also what is not believed. He also discussed how such a logic can capture default reasoning mechanisms. For instance, if all I know is that Tweety is a bird, and birds typically fly, then I come to believe that Tweety flies (unless, I am told otherwise).

Clearly, such a framework is also desirable in a many agent setting, so that one agent may capitalize on what she believes another agent to know, so as to coordinate tasks or plan strategies against another. Much work went in to extend this logic to the case with many agents, but unfortunately none without problems. The most recent solution, by Halpern and Lakemeyer, forces us to introduce proof-theoretic notions in the semantics, for instance.

In a recent paper (KR 2010), we introduce a new semantics, which we show has two notable properties. The semantics is natural, unlike the Halpern and Lakemeyer approach, and correctly captures the intuitions of only-knowing for the many agent case. The second property is that we have an axiomatization, that succinctly captures the properties of the new logic. So it appears, that for the first time, we have a natural generalization of Levesque’s logic, allowing us, besides other things, to capture knowledge-bases (and beliefs about opponent’s knowledge-bases) in a precise manner.

One of the main goals of Knowledge Representation, besides capturing the static beliefs of an agent, is to allow the agent to reason about the dynamics inherent in the world. For instance, an agent, say Alice, may want to reason that her opponent, say Bob, who just read his card knows what the card is, although Alice herself has no clue about it. A first-order dialect called the situation calculus is one formalism to reason about action and change. However, capturing knowledge in the situation calculus and proving properties pertaining to the beliefs of an agent is not straightforward. For this reason, Lakemeyer and Levesque propose a first-order modal logic, a logic called ES, that not only captures the main ideas of the situation calculus but also allows for easy semantic proofs.
In a multi-agent setting, one utility of such frameworks is in reasoning about beliefs and strategies in games. Indeed, we may want to reason about properties precisely like the card example above. It is well known in the game theoretic literature, for instance, that their standard models to capture beliefs are not expressive enough for such tasks.

In a recent paper (AAAI 2010), we build on our new semantics, to propose extensions to the logic ES. We show how knowledge about games can be captured in this new framework, and we also show how properties like the one discussed can be analyzed as logical entailments. Additionally, the situation calculus is endowed with a regression property, that allows one to reduce arbitrary entailments to a sentence that should hold initially. This way, one can reason about consequences after any history, all from the initial situation. We show that such a property exist when many agents are involved, and what they only-know is nested to some finite depth. Thus, if Alice believes that all the Bob knows are also just the rules of the game, then she knows that Bob cannot know what her cards are initially (just as she does not know what his cards are initially; its a fair game!).

Much of our work, in principle, should resort to first-order modal theorem proving. There are some techniques, such as the representation theorem introduced by Levesque and Lakemeyer, that may reduce reasoning to pure first-order theorem proving. But, reasoning about validity in first-order logic is undecidable. Our notion is that, in many interesting scenarios, full first-order expressivity is not needed. Thus, it may be possible to handle incomplete knowledge, and yet remain tractable in some sense. Some recent papers by Liu and Levesque, and Vassos and Levesque, look at such issues. The main idea is to typically reduce reasoning with incomplete knowledge to query evaluation in databases. It is, for instance, known that reasoning about queries that only use a bounded number of variables, is tractable. In fact, although it is exponential in the number of variables used, it is polynomial for some fixed bound. Our current interests lie in understanding and exploring tractability results in our framework, by restricting the types of logical theories (axiomatizations of the domains) that we reason with.
Other Activities

Program Committees
Gerhard Lakemeyer was PC member of numerous international conferences. He is on the Editorial Board of *Artificial Intelligence*, *Computational Intelligence*, and the *Journal of Applied Logic*, and a member of the Advisory Board of the *Journal of Artificial Intelligence Research*.

Stefan Schiffer was a PC member of the RoboCup Symposium in 2010 and of the ERLARS Workshop in 2010.

Dagstuhl Workshop “Cognitive Robotics”
Together with Hector Levesque and Fiora Pirri Gerhard Lakemeyer organized the Cognitive Robotics Workshop in Dagstuhl which took place between February, 21 – 26.

While the earlier workshops were largely a forum for presenting state-of-the-art research results, the purpose of the Dagstuhl event was to broaden the view and bring together people from various disciplines to shed new light on the issues in cognitive robotics. Among the participants were researchers from areas such as robotics, machine learning, cognitive vision, computational neuroscience, and knowledge representation and reasoning.

Service
Since October 2007, the Knowledge-Based Systems Group is hosting the RoboCup-@Home Wiki ([http://robocup.rwth-aachen.de/athomewiki](http://robocup.rwth-aachen.de/athomewiki)), a platform for researchers and participants in the RoboCup@Home league to foster exchange and collaboration and to facilitate progress in domestic service robotics.

Research Visits

- Prof. Gerhard Lakemeyer and Stefan Schiffer visited the University of Cape Town, South Africa, in December 2009, to work with Dr. Alexander Ferrein. Both gave a talk on their current research activities as part of an open house event at the Robotics and Agent Research Lab.

- Between March 2010 and June 2010, Prof. Gerhard Lakemeyer visited the University of New South Wales, Australia and the University of Toronto, Canada on a sabbatical. He collaborated with Prof. Pagnucco from Australia and Prof. Levesque from Toronto in the research area of cognitive robotics.

- In August 2010, Prof. Thomas Meyer from the Meraka Institute in South Africa visited our research group for a months. Prof. Thomas Meyer is known for
his work on belief revision, and ontologies. Currently, his main focus is on
description logics, and is one of the main researchers of the Knowledge Systems
Group at the Meraka Institute. He gave a short talk titled "Reasoning about
Ontologies using Description Logics" at the Informatik 5 Doctoral Seminar in
Bitburg.

• From September 2010 to December 2010, Prof. Hector Levesque from the Uni-
versity of Toronto is visiting our institute. Prof. Levesque will be collaborating
with Prof. Gerhard Lakemeyer on reasoning about knowledge and action.

• From September 2010 to July 2011, Radhakrishnan Delhibabu from Anna Uni-
versity, India is visiting our research group as part of a scholarship he received
from the India4EU European-funded project. Mr. Delhibabu’s research interest
primarily lie in the view-update problem and belief revision. His current focus
is at the intersection of the situation calculus and belief revision. He gave a short
talk on his past work at the Informatik 5 Doctoral Seminar in Bitburg.

Tournaments and Competitions

RoboCup German Open 2010. In April 2010, we participated in the RoboCup
German Open 2010 in the Middle Size League which took place in Magdeburg.

Demonstrations

Schüleruniversität 2010. The KBSG demonstrated the robot Caesar to students
participating the Schüler-Universität in August 2010. We explained some principal
methods in autonomous mobile robotics by showcasing a domestic service robotics
scenario and elucidating the underlying techniques.

China Aerospace. We demonstrated our domestic service robot Caesar to a dele-
gation of China Aerospace. While presenting and explaining the capabilities of our
autonomous mobile robot we discussed possible connecting factors.

Talks
Stefan Schiffer: Towards Integrated Self-Maintenance for Domestic Service Robotics,
DAIDO/RWTH Workshop on Metal Forming and Autonomous Systems, RWTH Aachen
University, Germany, October 2010.
Publications

Thomas Wisspeintner, Tijn van der Zant, Luca Iocchi, Stefan Schiffer: *RoboCup@Home: Scientific Competition and Benchmarking for Domestic Service Robots*, Interaction Studies, Special Issue: Robots in the Wild, 10(3), November, 2009


Sandra Geisler, Christoph Quix, Stefan Schiffer: *A Data Stream-based Evaluation Framework for Traffic Information Systems*, In Proceedings of the 1st ACM SIGSPATIAL International Workshop on GeoStreaming (IWGS 2010), November 2, San Jose, CA, USA, 2010
