Gerhard K. Kraetzschmar

Profile & Curriculum Vitae

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Short Profile

Name:	Gerhard K. Kraetzschmar
Dissertation:	Ph.D. (Dr.-Ing.) in Computer Science, University of Erlangen, 1996 Title: *Distributed Reason Maintenance for Multiagent Systems* Advisors: Prof. Dr. Herbert Stoyan, Prof. Dr. Hartmut Wedekind
Habilitation:	in preparation, University of Ulm, submission planned September 2005 Title: *Roaming and Locating Capabilities for Mobile Robots* Advisor: Prof. Dr. Günther Palm
Research Interests:	– adaptive autonomous agents – autonomous mobile robots – middleware for robotics and embedded systems – software engineering for ambient intelligence and robotics – educational and edutainment robotics – cooperative multiagent systems
Scientific Activities:	– acquired more than 1.1 million Euros in research funding as PI or Co-PI – project evaluator for European Commission FP 5 and FP 6 – reviewer for 5 journals, 30 conferences, and 15 workshops – organizer of 24 conferences and workshops – 13 invited talks – member of AAAI, ACM, IAS, IEEE, GI, TCSI
Teaching:	– 20 courses or lab courses – 16 seminars – 17 student project labs (Praktika) – 9 tutorials – 33 finished, 1 ongoing advised student projects or masters theses – 2 completed and 4 ongoing co-advised dissertations
Remarks:	– founded a RoboCup Team – initiated and founded The Cool Science Institute (TCSI) – founding partner of Wonderbits
References:	Prof. Günther Palm, University of Ulm Prof. Bernd Radig, Technical University of Munich Prof. Frans Groen, University of Amsterdam Prof. Manuela Veloso, Carnegie Mellon University Prof. Minoru Asada, Osaka University Prof. Enrico Pagello, University of Padua

Publications:	in press	published
– journals	1	9
– book chapters		8
– conferences and workshops	3	34
– invited contributions		5
– books		2
– editorial work		7
– technical reports		10
– other and non-refereed	1	20
– intellectual property rights		1

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1 Curriculum Vitae

1.1 Tabular Survey

proj. 09/2005	Submission of habilitation thesis.
04/2005 – today	University of Applied Sciences Bonn-Rhein-Sieg, Faculty of Computer Science, Professor for Autonomous Systems, part-time (2/3), in connection with part-time position (1/3) at fraunhofer AIS.
02/2005 – today	Fraunhofer Institute for Autonomous Intelligent Systems. Senior Research Scientist.
03/2003	NaT-Working Award of Robert-Bosch-Foundation.
06/2000	Foundation of *The Cool Science Institute*.
05/2000	E-commerce Innovation Award of Volksbank Ulm.
11/1999	Foundation of *Wonderbits*.
10/1997	Foundation of RoboCup team *The Ulm Sparrows*.
05/1997 – today	University of Ulm, Department of Neuroinformatics, research assistant professor.
04/1995 – 04/1997	University of Ulm, Department of Neuroinformatics, senior research scientist.
06/1996	Ph.D. in Computer Science (Dr.-Ing.), with distinction (summa cum laude).
02/1996	Submission of dissertation thesis.
04/1990 – 06/1996	University of Erlangen, Ph.D. studies in Computer Science.
02/1990 – 04/1995	FORWISS – Bavarian Research Center for Knowledge-Based Systems, Erlangen, research scientist.
06/1989 – 12/1989	Expertise GmbH, Berlin, division manager Lisp/Prolog products.
09/1988 – 05/1989	Technical University of Berlin, research scientist.
08/1980 – 08/1988	Freelance work and several summer internships at various companies.
05/1988	M.S. (Dipl.-Inf.) in Computer Science.
06/1984 – 05/1988	University of Erlangen, Computer Science Program.
08/1983 – 05/1984	California State University, Northridge, CA, USA, graduate program in Computer Science, Fulbright grant.
10/1980 – 07/1983	University of Erlangen, Computer Science Program.

1.2 Education

since 07/1996	**University of Ulm** Habilitation in Computer Science.
projected 09/2005	Submission of habilitation thesis. Title: *Roaming and Locating Capabilities for Mobile Robots*.
04/1990 – 06/1996	**Friedrich-Alexander-University of Erlangen-Nuremberg** Ph.D. program in Computer Science.
06/1996	Thesis defense and award of Ph.D. degree in Computer Science (Dr.-Ing.), final grade 1.0 ($\equiv$ 4.0 GPA), with distinction (*summa cum laude*).
02/1996	Submission of dissertation (in English, with special permission). Title: *Distributed Reason Maintenance*. Reviewers: Prof. Dr. Herbert Stoyan, Chair of Artificial Intelligence. Prof. Dr. Hartmut Wedekind, Chair of Database Systems.
06/1984 – 05/1988	**Friedrich-Alexander-University of Erlangen-Nuremberg** Master of Science program in Computer Science (Diplom-Informatik) with minor in Business Administration (contd. after exchange year in USA).
05/1988	Diploma (M.S.) in Computer Science, final grade 1.5 ($\equiv$ 3.5 GPA).
05/1988	Submission of diploma thesis (in English, with special permission), Chair of Database Systems (Datenbanksysteme, Prof. Dr. Hartmut Wedekind). Title: *Extending Object-Oriented Systems for Distributed Technical Applications*, graded 1.0 ($\equiv$ A).
01/1987	Final examinations, average grade 1.8 ($\equiv$ 3.2 GPA).
07/1986	Submission of study thesis. Chair of Business Computing (Wirtschaftsinformatik I, Prof. Dr. Dr. h.c. mult. Peter Mertens). Title: *Supporting Corporate Strategic Planning by a Knowledge-Based System Implemented in Prolog*, graded 1.3 ($\equiv$ A-).
08/1983 – 05/1984	**California State University at Northridge** Graduate School, Master of Science program in Computer Science, one year exchange program, funded by a Fulbright grant, 4.0 GPA.
10/1980 – 07/1983	**Friedrich-Alexander-University of Erlangen-Nuremberg** Master of Science program in Computer Science (Diplom-Informatik) with minor in Business Administration.
04/1983	Vordiplom (B.S. degree), grade 1.9 ($\equiv$ 3.1 GPA).

1.3 Work Experience

since 04/2005	**University of Applied Sciences Bonn-Rhein-Sieg**, Sankt Augustin. Professor for Autonomous Systems, Faculty of Computer Science (part-time 2/3, in connection with part-time position (1/3) at Fraunhofer AIS).
since 02/2005	**Fraunhofer Institute for Autonomous Intelligent Systems** (Fraunhofer AIS), Prof. Dr. Thomas Christaller, Schloss Birlinghoven, Sankt Augustin. Senior research scientist for educational robotics and behavior engineering.
04/1995–02/2005	**University of Ulm**, Department of Neural Information Processing, Prof. Dr. Günther Palm, until April 1997 research scientist, since May 1997 senior research scientist and research assistant professor.

- Co-PI in Project *Adaptivity and Learning in Teams of Cooperating Mobile Robots*, DFG Focal Point Programme SPP-1125 on *Cooperating Teams of Mobile Robots in Dynamic Environments*.
- Co-PI in Project *A Learning Autonomous Vehicle*, funded by state government of Baden-Württemberg.
- Founded and developed the robotic soccer team *The Ulm Sparrows* (since October 1997) for participation in world championships on robot soccer (RoboCup).
- Co-PI in subprojects of Collaborative Research Project 527 *Integration of Symbolic and Subsymbolic Information Processing in Adaptive Sensorimotor Systems*, funded by DFG.
- Founded and developed the Robotics Laboratory of the Faculty of Computer Science (initially used for teaching, since September 1996 also for research projects).
- Contributed to teaching. Advised numerous lab projects and diploma theses. Organized several seminars. Developed and taught own courses in the area of robotics, learning, agents, and artificial life.
- Participated in the coordination of hardware and software acquisitions and the installation, operation, and maintenance of the department's computing environment.

since 06/2000	**The Cool Science Institute** (TCSI) e.V., foundation of a non-profit organization to promote interest in science and technology among young people and cooperation between schools and universities.

- Initiated and founded TCSI.
- Elected as CEO.
- Acquired funding for pilot projects at eight schools in Bavaria and Baden-Württemberg from Robert-Bosch-Foundation.
- Acquired funding for pilot projects at Schubart High School from the Education Initiative of the City of Ulm.
- Acquired funding for the regional Robotics Competence Center Illertal *RoCCI* from the Education Initiative Bavaria and local business enterprises.
- Initiated cooperation with VDMA (Association of German Machining Industry) for promoting robotics activities at high schools. Joint exhibition during students day *go for high tech* at Hannover Industrial Fair.
- Organized annually RoboCupJunior GermanOpen, a robotics competition for high school students, since 2001. Participation since 2003 annually > 100 teams and > 300 students.
- Organized RoboCupJunior WorldCup 2004 in Lisbon. Participation > 170 teams and > 670 students from 17 countries.
- Received NaT-Working Award by Robert Bosch Foundation.

since 11/1999	**Wonderbits** Enderle, Dr. Kraetzschmar, Sablatnög and Simon GbR, foundation of spin-off company with partners Stefan Enderle, Stefan Sablatnög and Steffen Simon.

- Responsible for management and organization, presentation, and business development.

- *E-commerce* Innovation Award 2000 given by Volksbank Ulm for the *CyberStage* business idea, a platform for innovative online marketing.
- Design and development of product *Tetrixx*, a modular robot construction kit for science and education. Market introduction in January 2001.
- Made short list of 10 best business plans in CyberOne-2001 E-Business Award by Baden-Württemberg Connected.

02/1990 – 02/1995   **Bavarian Research Center for Knowledge-Based Systems (FORWISS)**, Knowledge Acquisition Research Group, Prof. Dr. Herbert Stoyan, Erlangen, research scientist.

- Project *Planning and Execution in Distributed Environments (PEDE)*.
- Project *WissAk – Assistants for Knowledge Acquisition*, part of FORWISS strategic project Human/Computer Interaction (MMK).
- Project KME (*Maintenance of Knowledge Bases*), cooperation project with BMW, Munich.
- Contributed to teaching; advised numerous study and diploma theses, and organized several seminars and other courses.
- Contributed to organization and development of the Chair for Artificial Intelligence, e.g. planned and acquired the department's hardware and software environment.
- Participated in the computing and networking group, an internal committee for coordinating computing services and supervising technicians and operators.

06/1989 – 12/1989   **Expertise GmbH**, Berlin, project manager, division manager Prolog/Lisp products.

- Managed Prolog/Lisp products division (marketing, sales, support for Quintus Prolog and Allegro Common Lisp product families and their add-on products, and other Prolog- and Lisp systems).
- Acquired sales licenses for new products.
- Acquired consulting and development projects, and consulted and contributed to these projects.
- Planned and administered computing environment for Expertise (including Sun Workstations/SunOS, Macintosh/MacOS, PCs running UNIX and MS-DOS, and their networking).
- Trained and supervised employees for Prolog/Lisp division.

09/1988 – 05/1989   **Technical University of Berlin**, Chair for Systems Analysis (Prof. Dr. Herrmann Krallmann), research scientist, project *INTERBIT*.

- Contributed to planning and organization of project.
- Performed and supervised research on distributed object-oriented systems.
- Prepared proposals for EC projects (RACE, BRITE/EURAM).
- Contributed services to other projects, e.g. cooperation with DEC in Munich and Marlboro, USA.
- Participated in teaching (coordinated seminar *Distributed Artificial Intelligence*, including invitation of external speakers).
- Advised study and diploma theses.

The work experience listed below was collected while simultaneously studying full-time.

01/1986 – 08/1988   **Expertise GmbH**, Berlin, consultant.

- Contributed to all activities related to the development and expansion of the company: management and organization, project acquisition and consulting, marketing, support, research and development, education and training.
- Developed and expanded German market for Quintus Prolog.
- Supervised several trainees of the GNB Gesellschaft für Neue Berufe, a school educating knowledge engineers.

01/1986 – 11/1986   **TA Triumph-Adler AG**, Nuremberg, consultant for Department of Basic Research and Fundamental Technologies.

- Contributed to government-funded (BMFT) multipartner project *WISDOM*, especially to the design and implementation of the expert system shell *LUDWIG* (later renamed *LUIGI* and *KnowledgeWorks*).
- Designed and implemented *CALLIGRAPHY*, a graphical editor for knowledge bases.
- Contributed to other scientific activities in the department, like preparation of presentations and technical reports.

10/1985 – 12/1985   **Grundig Academy**, Nuremberg, part-time lecturer.

- Lectured courses *Introduction to Computing* and *Software Engineering*.

03/1985 – 09/1985   **NAS GmbH**, Erlangen, part-time employee.

- Designed and implemented a multitasking operating system layer (using MS-PASCAL on MS-DOS), including an integrated interface to custom-designed local networking hardware for industrial process control.

06/1984 – 02/1985   **BASYS GmbH**, Nuremberg, part-time employee.

- Designed and implemented procurement systems, inventory control systems, and billing systems, using MS-COBOL and MS-DOS on PCs.

08/1981 – 04/1983   **ELDICON GmbH**, Nuremberg, part-time employee.

- Designed form system for establishing quality control.
- Designed and implemented a user interface for the control unit of a robotic manipulator as part of government-funded (BMFT) research project.

02/1981 – 07/1981   **University of Erlangen**, Chair of Operations Research (Prof. Dr. Manfred Meyer), research assistantship.

- Programmed graphical visualization algorithms in FORTRAN.

1.4 Personal Data

Birthday: July 30, 1961.
Marital Status: Married.
Children: One son, 12 years old.

1.5 Personal Interests

Sports: Basketball
                    Soccer
                    Running
                    Downhill Skiing
Leisure: Music
                    Architecture
                    Graphics and Design
                    Economics and Politics
                    Italian and Asian cuisine
Languages: German
                    English

2 Professional and Scientific Activities

2.1 Professional Development

Studies in Artificial Intelligence: Very early in my studies of computer science (1981), my interest in science was raised and strongly encouraged by Herbert Stoyan at University of Erlangen. Herbert Stoyan was a highly recognized AI expert and, at that time, author of the only working Lisp implementation in the former East Block countries. After his emigration to West Germany, he worked in the Department of Database Systems at University of Erlangen and started to give courses on artificial intelligence. The inherent multidisciplinary nature of this field matched well with my own interdisciplinary interests, and I became very interested in artificial intelligence (AI).

The next forming step in my scientific development was a year of studying in the United States, at California State University at Northridge (CSUN), on a Fulbright grant. Aside of courses at my host university, I attended AI courses at UCLA as guest, and listened to numerous invited talks at UCLA and Caltech. This intensive acquaintance with the American educational system (later on enhanced by visiting friends spending time at various other American universities) has strongly influenced both my research activities and teaching approach.

After returning to University of Erlangen, I first wrote my study thesis and later my Diploma thesis. Both benefitted enourmously from the application of what I learned from Herbert Stoyan, and my knowledge of the logic programming language Prolog, which I obtained at CSUN. In my study thesis (submitted 1986), I applied principles of object-oriented design and object-oriented programming, which allowed for a much simpler implementation of a knowledge-based system for corporate strategic planning: Instead of a knowledge base containing over 3000 rules using the HEXE expert system shell developed by the department of Prof. Peter Mertens, the Prolog-based system developed by myself required only about 150 objects (instances) and just 10 rules for representing the same expert knowledge. In my Diploma thesis submitted to the Department of Database Systems, chaired by Prof. Hartmut Wedekind, I could build on my interest in object-oriented techniques and showed, how beneficial such techniques can be applied in areas like Computer-Integrated Manufacturing (CIM, CAD, CAM, CAE). The thesis presented several novel ideas with regard to object-oriented languages and their implementation in Prolog, including dynamic binding of methods, unification of method calls, and backtracking over message passing. These ideas caught the interest of scientists at the Chair of Systems Analysis and EDP at Technical University of Berlin (Prof. Dr. Herrmann Krallmann). I moved to Berlin to work in the INTERBIT project, part of the large BERKOM project. Unfortunately, this project had still funding problems nine months after I started there. I decided to leave and took an intermediate position as Division Manager Lisp/Prolog Products at Expertise GmbH, where I had already worked part-time as consultant during my studies.

Knowledge Engineering and Knowledge Management: Early in 1990, I was offered an opportunity to return to Erlangen. The position asked for contributions to the development of both the research group on knowledge acquisition at FORWISS and the research group of the new Chair on Artificial Intelligence, headed by Prof. Herbert Stoyan. At FORWISS, I first did research on the maintenance of knowledge bases. We analyzed this wide, but (at that time) unstructured domain and defined eight potential working areas. Together with our project partner BMW we selected the semi-automated generation of graphical user interfaces (GUIs) for maintenance of knowledge bases by users having no specific knowledge of the underlying knowledge representation systems and techniques as the focus of our further research. Based on first results in this direction, we could attract ABB as partner in another research project on knowledge base maintenance. In the latter project it soon became clear that, aside of maintaining formalized knowledge, managing the informal knowledge of the operators and users working in the application scenario is essential. In project WissAk, we developed the *Knowledge Mining Center*, a tool for acquiring and structuring informal expert knowledge and a direct ancestor of today's knowledge management techniques.

Multiagent Systems and Distributed Artificial Intelligence: In both knowledge base maintenance projects, the expert systems' knowledge bases developed by our project partners BMW and ABB modelled complex technical procedures or processes. I became interested in methods for automatic planning and execution of such complex processes and studied more intensively the AI areas of planning, scheduling, distributed problem solving, and multiagent systems. With the PEDE-Lab software we implemented a simulation environment and testbed for complex, distributed planning and scheduling problems. In two diploma theses, which where done in cooperation and joint supervision with the Daimler-Benz production site in Sindelfingen, PEDE-Lab was used to model and analyze Just-in-Time procurement

processes in automobile manufacturing. In our research, we could show how the stock of an emergency inventory of inside covers for doors used in cars could be reduced by over 90%, without increasing the risk of production failures significantly. Another surprising result, even for Daimler-Benz, was that the phenomena responsible for installing the emergency inventory in the first place could be predicted by the simulation and explained as phase transition in dynamical systems.

The investigation of formal approaches to modelling multiagent systems, especially for planning and scheduling, quickly uncovered an open problem: how can we model assumptions and dependencies between data, e.g. the actions in a multiagent plan, in multiagent systems? The capability to efficiently maintain multiple contexts (based on different sets of assumptions) was another essential requirements for reasons of practicality and flexibility. In standalone, single agent applications, *reason maintenance* and *belief revision* techniques were applied. However, the computational resources required by these systems were impractical, because exponentially growing, when representing multiple contexts. My Ph.D. thesis was devoted to solve this problem. I developed *facet logics* for the formal specification and characterization of *belief states* in multiagent systems, and the systems *XFRMS* and *MXFRMS* for the efficient maintenance of data dependencies and multiple contexts in the single agent and multiagent case, respectively.

Robotics and Neuroinformatics: A decisive turning point of my scientific interests was my participation in the *Robot Building Laboratory* of the AAAI-93 conference in Washington, D.C. Organizing such robot building labs was for some time the only opportunity to follow my now viable interest in robotics. In spring 1995, I was offered the opportunity to join the interdisciplinary research group of Prof. Günther Palm at the University of Ulm. The School of Computer Science was preparing an application for the DFG for an interdisciplinary Collaborative Research Project (Sonderforschungsbereich, SFB) on the integration of symbolic and subsymbolic information processing in sensorimotor systems, which was successfully reviewed and installed in early 1997. In parallel, a robotics lab for both research and teaching was created and developed. I started to study neuroscience and neural network technology, and, within the SFB, researched and supervised projects in the areas of robot control architectures, neurosymbolic integration in spatial cognition, and reinforcement learning, in particular for behavior-based architectures and continuous state spaces.

For our demonstrator, a B21 robot from RWI, we built the CORBA-based middleware *Miro*, an implementation framework for robot control architectures meeting the requirements of modern, distributed software development methods. The spatial representation and reasoning architecture *DYNAMO* was developed to allow multimodal representation of very large environments and applied in the hybrid, multilevel robot navigation system *Columbus*. In the near future, we will integrate functionality for hierarchical visual object classification, which was also developed in our group. This work was continued in project *A learning autonomous vehicle*, a project in the focal research program of the state government of Baden-Württemberg. The goal of this research is to build a reliable service robot, which can operate safely in a very large, dynamic office environment, carry out services like delivery tasks or guided tours, and interact and communicate with humans in interesting and entertaining ways.

At the end of 1997 we started to build, primarily for educational purposes, a team of robotic soccer players for the RoboCup research initiative (see `www.robocup.org`). For RoboCup-98 we modified the Pioneer-1 robots that were already available in our lab for teaching. For RoboCup-99, our team designed and implemented the *Sparrows* robot, a new, custom-made soccer robot which featured significantly improved soccer-playing capabilities and built the foundation for numerous subsequent research activities. In 2000, our RoboCup team demonstrated the feasibility of the Monte-Carlo localization approach, if available sensor data consists only of sparse and sporadic visual features. In 2001, we ported the *Miro* middleware to the Sparrows robots and redesigned our behavior-based control architecture. In addition, we started to evaluate the suitability of learning techniques for behavior adaptation and situation classification. These are also the main research topics of our project within the DFG focal point research program SPP-1125.

In order to reduce required training time for new students in our RoboCup team, we organized a robot building laboratory at the University of Ulm in February 1998. In May 1998, we offered this course to high school students located in Ulm and its vicinity. The course was very well received by its participants. Subsequently, it generated so much interest for further courses, that it is obviously infeasible for universities to satisfy this interest. Ignited by similar developments in the United States, Italy, and Denmark, the idea of organizing robot building laboratories directly at high schools emerged. This idea was implemented in 2000 by founding the non-profit organization *The Cool Science Institute* (TCSI) and successfully acquiring funding for a number of pilot projects in schools.

The research activities and results achieved in various activities like SFB, RoboCup, and TCSI are converging towards *edutainment robotics*, a new, emerging field rated by many people as probably the most interesting and challenging research area of robotics for the next decade.

2.2 Research Projects

For all projects listed below I wrote the project proposal or contributed at least major parts of it.

2.2.1 Ongoing Projects

- **Adaptivity and Learning in Teams of Cooperating Mobile Robots**, subproject in DFG Focal Point Program SPP-1125 *Cooperating Teams of Mobile Robots in Dynamic Environments*. Co-PI.
  >330,000 Euro
- **The Ulm Sparrows**, RoboCup team of the University of Ulm, funding by the University of Ulm, the Society of the University of Ulm, MFG Medien- und Filmgesellschaft Baden-Württemberg, and others. Co-PI. > 120,000 Euro
- **EURON: European Robotics Research Network**, member node.
- **RoCCI: Robotics Competence Center Illertal**, at Illertal-Gymnasium Vöhringen-Illerzell. Funded by Bavarian Government and Legoland Günzburg within the Bavarian Education Initiative. Co-Coordinator, teaching and project consultancy. 50.000 Euro
- **Robot Building Labs** at eight high schools in Bavaria and Baden-Württemberg. Organized by *The Cool Science Institute*. Funded by the Robert-Bosch-Foundation, Stuttgart. Coordinator and PI. 82,318 Euro
- **Robot Building Labs** at Schubart High School Ulm. Organized by *The Cool Science Institute*. Funded by the Education Initiative of the City of Ulm. Coordinator and PI. 15,338 Euro

2.2.2 Finished Projects

- **Structured Reinforcement Learning in Continuous State Spaces**, project in program "Project Seed Funding for Young Scientists" at the University of Ulm. 10,230 Euro
- **A Learning Autonomous Vehicle**, project in the research focus program of state government of Baden-Württemberg. Co-PI. 127,300 Euro
- **Neurosymbolic Integration and Spatial Representation and Reasoning**, subproject C1 in Collaborative Research Project SFB-527. Co-PI, project managment. 254,400 Euro
- **Integration of Heterogeneous Neural Nets and Neural Assessment of Actions in Sensorimotor Systems**, subproject B3 in Collaborative Research Project SFB-527. Co-PI, project management.
  166,800 Euro
- **EPK-fix: Generation of Electronic Product Catalogs**, BMBF joint project, FORWISS and mediatec GmbH, TH Darmstadt, LMU Munich and TU Dresden. Conceptualization and planning of project (jointly with Dr. Schneeberger, Prof. Stoyan and others).
- **WissAk: Assistants for Knowledge Acquisition**, FORWISS project Human/Computer Interaction (MMK). Research scientist. Project management (jointly with Prof. Stoyan).
- **KME-ABB: Maintenance of Knowledge Bases**, cooperation project of FORWISS and ABB, Mannheim. Research scientist. Project planning (jointly with Prof. Stoyan).
- **KME-BMW: Maintenance of Knowledge Bases**, cooperation project of FORWISS and BMW, Munich. Research scientist.

2.3   Talks and Presentations

2.3.1   Invited Talks

- *Mixed Societies and Sports*, Symposium Building Mixed Societies of Animals and Robots, Fondation de Treilles, France, April 2005.
- *Educational Robotics*, Technikerschule Nördlingen, Nördlingen, November 2003.
- *Educational Robotics*, Learning Lab Lower Saxony, Hanover, April 2003.
- *The Cool Science Institute*, University of Mainz, Mainz, May 2002.
- *RoboCup – Aims, Leagues, and Rules*, RoboCup-CAMP, an international spring school on RoboCup, Paderborn, April 2002.
- *Research Problems for Robotic Soccer Players*, Conference on Autonomous Minirobots for Research and Education (AMiRE-2001), Paderborn, October 2001.
- *Perceptual Problems for Robotic Soccer Players*, Workshop Vision-Based Object Recognition in Robotics, Intl. Symposium on Computational Intelligence in Robotics and Automation (CIRA-2001), Banff, Canada, July 2001.
- *Levels of Autonomy and Cooperation in Multiagent and Multirobot Systems*, Instituto de Sistemas e Robotica, Instituto Superior Tecnico (Technical University of Lisbon), Lisbon, March 2001.
- *The Cool Science Institute*, Instituto de Sistemas e Robotica, Instituto Superior Tecnico (Technical University of Lisbon), Lisbon, March 2001.
- *Integration of Multiple Representations and Navigation Concepts on Autonomous Mobile Robots* Workshop SOAVE-2000: Self-Organization of Adaptive Behavior, Ilmenau, October 2000. (in German)
- *The Cool Science Institute*, Workshop Edutainment Robotics 2000, Bonn, September 2000.
- *RoboCup*, Incognito Symposium *A Robot's Perspective*, University of Utrecht, April 1999.
- *DAI Tools and Programming Environments*, Foundation Workshop of GI Special Interest Group on Distributed Artificial Intelligence, Saarbrücken, April 1994. (in German)

2.3.2   Talks at Conferences and Workshops

- *Software Engineering for Autonomous Mobile Robots: Problems and Desirables*, ICRA-05 Workshop on Principles and Practices of Software Development in Robotics, Barcelona, April 2005.
- *Adaptive Color Classification in RoboCup*, SPP-1125 Workshop on Towards a National Robot Soccer Team, Berlin, November 2003.
- *Supporting Community Integration with Middleware for Robots*, SPP-1125 Workshop on Towards a National Robot Soccer Team, Berlin, November 2003.
- *Robot Building Labs - A Method to Get Attention*, NaT-Working Workshop on Teaching Science in High Schools, Stuttgart, November 2003.
- *RoboCup Middle-Size League: The Past, State of the Art, and Future Challenges*, RoboCup Symposium, Padova, July 2003.
- *Neurosymbolic Spatiotemporal Structures fur Situation Clarification and Action Selection in Noisy, Dynamic Environments*, Workshop on Plan-Based Control of Robotic Agents, Dagstuhl, June 2003.
- *Using Educational Robotics to Teach Computer Science to High School Students*, Nat-Working Workshop Computer Science in High Schools, Trochtelfingen, April 2003.
- *Representing and Learning Spatial Maneuvers in Multirobot Teams*, SPP-1125 Workshop Adaptive Cooperative Multirobot Teams in Dynamic Environments, St. Augustin, March 2003.
- *Towards Autonomous Vision Self-Calibration for Soccer Robots*, International Conference on Intelligent Robots and Systems (IROS-2002), Lausanne, Switzerland, October 2002.
- *Hybrid Spatial Representations for Autonomous Mobile Robots* on Plan-Based Control of Robotic Agents, Dagstuhl, October 2001.
- *Improving Vision-Based Self-Localization*, RoboCup-6 Symposium, Fukuoka, Japan, Juni 2002.
- *Miro: Middleware for Autonomous Mobile Robots*, Telematics Applications in Automation and Robotics, Weingarten, July 2001.
- *Soccer Robot Localization Using Sporadic Visual Features*, Intelligent Autonomous Systems 6 (IAS-6), Venice,

July 2000.

- *Using Neurosymbolic Integration in Modelling Robot Environments*, NIPS-98 Post-Conference Workshop on Hybrid Neural Symbolic Integration, Breckenridge, CO, USA, December 1998.
- *Using Distributed and Temporal Reason Maintenance Techniques for the Representation of Dependencies and Constraints in Process Planning and Scheduling*, AAAI-94 Workshop on Reasoning About the Shop Floor, Seattle, July 1994.
- *PEDE-Lab – A Knowledge-Based Modelling and Simulation Environment and Its Application in Business Process Reengineering*, AAAI-94 Workshop on Artificial Intelligence in Business Process Reengineering, Seattle, July 1994.
- *Communicated Beliefs and Consistency in Multi-Agent Systems*, Conf. on Solving Complex Problems with Agent Systems, Bielefeld, June 1994.
- *Distributed Plan Maintenence for Scheduling and Execution*, KI-93 Workshop Planning and Execution in Distributed Environments, Berlin, September 1993.
- *PEDE-Lab: Testbeds for Manufacturing Applications*, AAAI SIGMAN Workshop on Intelligent Manufacturing Technology, Washington, D.C., USA, July 1993.
- *VKI Tools und Experimentierumgebungen*, (in German), Founding Workshop of GI SIG 1.1.6 VKI (Distributed Artificial Intelligence), Saarbrücken, May 1993.
- *Supporting Assumption-Based Reasoning in a Distributed Environment*, Workshop Distributed Artificial Intelligence (DAI-93), Hidden Valley, PA, USA, March 1993.
- *Inheritance in Programming Languages Revisited: Some Problems and Steps Towards Their Solution*, Workshop on Inheritance Hierarchies in Knowledge Representation and Programming Languages, Viareggio, Italien, February 1989.
- *STRATEX - ein prototypisches Expertensystem zur Unterstützung der strategischen Unternehmensplanung* (in German, with P. Mertens and E. Plattfaut), Society for Corporate Strategic Planning (GSP), GSP Spring Conference, March 1987.
- *Wissensbasierte Systeme in Prolog*, KOMMTECH'86, Essen, May 19986

2.3.3 Poster Presentations at Conferences and Workshops

- *Educational Robotics*, NaT-Working Workshop on Innovative Physics Education in High Schools, Berlin, January 2004
- *TCSI Robot Building Labs*, NaT-Working Annual Workshop, Munich, March 2003.
- *The Cool Science Institute*, NaT-Working Annual Workshop, Berlin, March 2002.
- *Adaptive Hierarchical Object Classification for Autonomous Mobile Robots*, International Conference on Artificial Neural Networks (ICANN 2002), Madrid, Spain, August 2002.
- *Miro: Middleware for Soccer Robots*, Symposium RoboCup-2001, Seattle, WA, U.S.A., August 2001.
- *Tetrixx – a robot development kit*, 1st Intl. Workshop on Edutainment Robots, St. Augustin, September 2000.
- *Vision-Based Localization in RoboCup Environments*, Workshop RoboCup-2000, Melbourne, Australia, August 2000.
- *The Wall Histogram Method*, Intl. Conference on Artificial Neural Networks (ICANN-99), Edinburgh, October 1999.
- *One Sensor Learning From Another*, Intl. Conference on Artificial Neural Networks (ICANN-99), Edinburgh, October 1999.
- *Adaptive Hybrid Spatial Modeling*, Workshop Navigation in Biological and Artificial Systems, Tübingen, April 1999.
- *FRMS: A Focus-Based Reason Maintenance System*, 15th Intl. Joint Conferences on Artificial Intelligence (IJCAI-97), Nagoya, Japan, August 1997.
- *Managing Multiple Contexts Efficiently*, Annual German Conference on Artificial Intelligence (KI-96), Dresden, September 1996.

2.4 Professional Activities

2.4.1 Membership in Professional Associations

- American Association for Artificial Intelligence (AAAI)
    - SIGMAN Special Interest Group on Artificial Intelligence in Manufacturing
- Association of Computing Machinery (ACM)
    - SIGART Special Interest Group on Artificial Intelligence
- The Institute of Electrical and Electronics Engineers (IEEE)
    - Computer Society
    - Robotics and Automation Society
    - Systems, Man and Cybernetics Society
- Intelligent Autonomous Systems Society
- Gesellschaft für Informatik (GI)
    - Founding member of Special Interest Group 1.1.6 (DAI) on Distributed Artificial Intelligence.
    - Member of Chairing Committee of Special Interest Group 1.1.6 (DAI) in 1995 and 1996.

The World Championships in Robotic Soccer, also known as RoboCup and held annually since 1997, are organized by the RoboCup Federation, which currently does not yet feature formal membership. In the RoboCup Federation I am – aside of various functions related to organizing specific events and tournaments – active in the following formal committees since 1999:

- RoboCup Federation Trustees Board (since July 2004)
- RoboCup Federation Executive Committee
- Middle-Size Robot League Committee
- RoboCupJunior Committee

2.4.2 Organization of Conferences and Workshops

- *RoboCup-2004, RoboCupJunior Tournament*, Lisbon, 2004. Chair Organizing Committee.
- *RoboCup-2004, Middle-Size Robot League Tournament*, Lisbon, 2004. Co-Chair Technical Committee.
- *RoboCup German Open 2004*, Paderborn, 2004. Co-Chair Junior League.
- *Executive Committee Strategic Workshop on the Future of RoboCup*, Blaubeuren, 2003. Local Organizer.
- *RoboCup-2003, Middle-Size Robot League Tournament*, Padua, 2003. Co-Chair Technical Committee.
- *RoboCup-2003, RoboCupJunior Tournament*, Padua, 2003. Co-Chair Organizing Committee.
- *RoboCup German Open 2003*, Paderborn, 2003. Co-Chair Junior League.
- *EURON Summer School on Cooperative Robotics 2002*, Lisbon. Organizing Committee.
- *Autonomous Agents and Multiagent Systems (AAMAS-2002)*, Bologna, 2002. Co-Chair Robot Demonstrations Track.
- *RoboCup German Open 2002*, Paderborn, 2002. Chair Junior League.
- *Reasoning about Uncertainty in Robotics*, Workshop at IJCAI-2001, Seattle, 2001. Workshop Organizing Committee.
- *RoboCup-2001 Middle-Size Robot League Tournament*, Seattle, 2001. Co-Chair Technical Committee, Member Organizing Committee.
- *RoboCup German Open 2001*, Paderborn, 2001. Chair Junior League.
- *Workshop RoboCup-2000*, Melbourne, 2000. Workshop Co-Chair.
- *RoboCup-2000 Middle-Size Robot League Tournament*, Melbourne, 2000. Co-Chair Technical Committee.
- *Autonomous Agents 2000*, Barcelona, 2000. Co-Chair Robot Demonstrations Track.
- *RoboCup-Euro-2000: European Robot Soccer Championships*, Amsterdam, 2000. Conference Co-Chair.

- *RoboCup-99 Middle-Size Robot League Tournament*, Stockholm, 1999. Chair Organizing Committee, Chair Technical Committee.
- *Adaptive Spatial Representations of Dynamic Environments*, IJCAI-99 Workshop ROB-2, Stockholm, 1999. Workshop Co-Chair.
- *IK-97: Interdisciplinary College 1997*, Günne am Möhnesee, 1997. Organizing Committee.
- *KIFS-96: Spring School on Artificial Intelligence*, Günne am Möhnesee, 1996. Program Committee, Organizing Committee.
- *MASSIM-96; Multiagent Systems and Simulation*, joint workshop of GI SIGs 1.1.6. and 4.5.3, Ulm, 1996. Workshop Co-Chair.
- *Agent-Oriented Techniques for the Specification and Implementation of Multiagent Systems*, workshop at Annual German Conference on Artificial Intelligence (KI-94), Saarbrücken, 1994. Workshop Co-Chair.
- *Distributed Artificial Intelligence*, 5. workshop of GI Working Group on Distributed Artificial Intelligence, Erlangen, 1992. Workshop Chair.
- *Reflection, Introspektion and Meta-Level Architekturen*, workshop of GI Special Interest Group (SIG) 1.1.1 (Declarative Programming), Erlangen, 1991. Workshop Co-Chair.

2.4.3 Reviewing for Funding Organizations

- EU FP6, FET, SO Complex Systems, ECAgents Project Evaluator, 2003
- EU FP5, FET Open, LEURRE Project Evaluator, 2003, 2004.
- EU FP6, 2nd Call, IST Strategic Objective *Cognitive Systems*, 2003
- EU FP6, 1st Call, IST Strategic Objective *Multimodal Interfaces*, 2003

2.4.4 Reviewing for Journals

- IEEE Transactions on Robotics and Automation, 2003
- Robotics and Autonomous Systems, 2000, 2002, 2004, 2005
- Biological Cybernetics, 2000
- Künstliche Intelligenz, 2000
- Neural Networks, 1997

2.4.5 Reviewing for Conferences

(including program committee invitations)

- German Annual Conference on Artificial Intelligence (KI) 2005
- RoboCup Symposium 2005
- Intelligent Robots and Systems (IROS) 2005
- Autonomous Agents and Multiagent Systems (AAMAS) 2005
- Field and Service Robotics (FSR) 2005
- Informatics in Control, Automation, and Robotics (ICINCO) 2005
- German Annual Conference on Artificial Intelligence (KI) 2004
- RoboCup Symposium 2004
- Intelligent Robots and Systems (IROS) 2004
- Inteligent Autonomous Vehicles (IAV) 2004
- Autonomous Agents and Multiagent Systems (AAMAS) 2004
- Intelligent Autonomous Systems (IAS-8) 2004
- IFIP Conference on IT and Sports 2004
- German Conference on Multiagent System Technologies (MATES-2003)
- RoboCup Symposium 2003
- Autonomous Agents and Multiagent Systems (AAMAS) 2003

- Intelligent Autonomous Systems (IAS-7) 2002
- Autonomous Agents and Multiagent Systems (AAMAS) 2002
- RoboCup Symposium 2002
- Autonomous Agents 2001
- RoboCup Symposium 2001
- Autonomous Minirobots for Research and Edutainment (AMiRE-2001)
- Autonomous Agents 2000
- Intelligent Autonomous Systems (IAS-6) 2000
- International Joint Conferences on Neural Networks (IJCNN-2000)
- International Conference on Artificial Neural Networks (ICANN-99)
- German Annual Conference on Artificial Intelligence (KI-99)
- Neural Information Processing Systems (NIPS-98)
- International Conference on Artificial Neural Networks (ICANN-98)
- German Annual Conference on Artificial Intelligence (KI-96)

2.4.6 Reviewing for Workshops

- *ICRA-05 Workshop on Cooperative Robotics*, Barcelona, 2005.
- *Neurobotics*, Workshop at KI-2004, Ulm, Germany.
- *Methods and Technology for Empirical Evaluation of Multiagent Systems and Multirobot Teams*, Workshop at KI-2004, Ulm, Germany.
- *Self-Organization of Adaptive Behavior* (SOAVE), Ilmenau, 2004.
- *IROS-02 Workshop on Cooperative Robotics*, Lausanne, 2002.
- *Edutainment Robotics 2000*, 1st International Workshop, Bonn, 2000.
- *Workshop RoboCup-2000*, 4th International Workshop, Melbourne, 2000.
- *Workshop RoboCup-99*, 3rd International Workshop, Stockholm, 1999.
- *Workshop RoboCup-98*, 2nd International Workshop, Paris, 1998.
- *Distributed Cognitive Systems*, Workshop at Annual German Conference on Artificial Intelligence (KI-97), Freiburg, 1997.
- *Learning, Adaption and Self-Organization in Distributed Intelligent Systems*, Workshop at Annual German Conference on Artificial Intelligence (KI-96), Dresden, 1996.
- *Learning in Distributed Artificial Intelligence Systems*, Workshop at European Conference on Artificial Intelligence (ECAI-96), Budapest, 1996.
- *Decision Theory for DAI Applications*, Workshop at European Conference on Artificial Intelligence (ECAI-94), Amsterdam, 1994.
- *PEDE: Planning and Execution in Distributed Environments*, Workshop at Annual German Conference on Artificial Intelligence (KI-93), Berlin, 1993.
- *Distributed Artificial Intelligence*, Founding Workshop of GI SIG 1.1.6 VKI, Saarbrücken, 1993.

2.5   Entrepreneurship

Through my early part-time employment by various engineering and software companies I developed a deep interest in technology transfer and entrepreneural activities. Especially the founder and executive manager of Expertise GmbH involved me in almost all business and management decisions and allowed me to gain valuable experience.

Even after my decision to follow an academic career, I could continue to develop my leadership qualities by building and growing teams and organizations. Examples are management activities in the Knowledge Acquisition Research Group at the Bavarian Research Center for Knowledge-based Systems (FORWISS), the foundation and development of the Chair for Artificial Intelligence at University of Erlangen, the foundation and development of the robotics laboratory at the University of Ulm, the preparation and management of the SFB 527 Collaborative Research Center, and the foundation and management of the RoboCup team *The Ulm Sparrows*.

Together with my three Ph.D. students Stefan Enderle, Stefan Sablatnög, and Steffen Simon I founded *Wonderbits* in late 1999. The company develops products exploiting adaptive autonomous agents technology. In particular, Wonderbits integrates innovative technologies from autonomous mobile robots, sensorimotor systems, adaptive systems, neural learning, distributed systems, and the Internet. Our product concept *CyberStage* was awarded one of three E-Commerce Innovation Awards by Volksbank Ulm in May 2000. Our product *Tetrixx*, a modular robot construction kit for education and research, is marketed since March 2001. In the CyberOne-2001 E-Business Award, a business plan competition, the Wonderbits business plan was chosen on the short list of the ten best entries (out of 74).

In June 2000 I initiated the foundation of the non-profit organization *The Cool Science Institute* (TCSI), which aims at developing and growing the interest of young (high school) students in science and technology, and at building a network for improving the cooperation between schools and universities. At the foundational meeting, I was elected Chief Executive Officer. TCSI is registered and recognized as tax-exempted non-profit organization by the German tax offices. TCSI tries to achieve its goals by initiating robot building labs in schools, where students can build and program small robots. We won funding of over 82.000 Euro from the Robert-Bosch-Foundation for pilot projects at eight high schools in Bavaria and Baden-Württemberg, about 15.000 Euro from the City of Ulm for projects at Schubart High School in Ulm, and 50.000 Euro from the Bavarian Education Initiative for starting RoCCI, a regional robotics competence center at Illertal-Gymnasium Vöhringen. Meanwhile, we helped about 40 schools to raise funding for robot kits, and more than 60 teachers and over 500 students are working in robot building labs. They have participated in regional and national competitions and won numerous national titles and awards. More than 25 teams and over a hundred students have very successfully participated in international competitions around the world (Melbourne, Seattle, Fukuoka, Padova) and won numerous world championships. TCSI has won VDMA, one of the largest industrial associations in Germany with over 3000 member companies, as a strategic partner.

3 Teaching

3.1 Teaching Statement

My approach to teaching is guided by a deep desire to offer learning opportunities to students, which allow them to develop and strengthen their knowledge and skills so that they can fully unleash their potential in their later careers.

In order to get students to perform at their maximum level, I consider motivation an essential prerequisite. Therefore, I always try hard to motivate students by giving examples, by providing intuitive illustrations and analogies, and connecting theoretical concepts to cases of practical applications. Exercises and homework are designed such that students deepen their understanding of theoretical concepts by hands-on experience and learning-by-doing.

Many good computer scientists cannot fully exploit their career potential due to underdeveloped personal and communication skills. Giving continuously feedback to student work like seminar talks, term papers, or theses work through constructive criticism and practical hints therefore goes without saying. Making use of techniques like video analysis of seminar talks can help students to quickly improve their presentation skills.

I also have a long tradition in trying alternative concepts in teaching. One example is the compact seminar, where a group of students and teachers meets over a weekend in some off-campus meeting place in a workshop-like manner. This organizational form leads to very intense discussion on subject topics, offers more time to devote to soft skill development, and opportunities for student group activities. Another example is our RoboCup team, which is considered a continuous learning effort by participating students, where they as a team have the opportunity to design and build complete complex physical systems like our soccer robots.

Last but not least, I am very flexible in my teaching style and willing to adhere to local traditions and constraints.

3.2 Teaching Interests

Aside of introductory and advanced courses in most core areas of computer science, I can teach a range of special courses, e.g. on autonomous mobile systems, multiagent systems, artificial intelligence, neuroinformatics, and software engineering for complex technical systems.

My teaching interests on the gradate level concentrate on the areas of autonomous mobile systems, adaptive autonomous agents, multiagent systems, artificial intelligence, neuroinformatics, and artificial life. Currently, I am also teaching courses on software development and software engineering for distributed embedded systems.

On the undergraduate level, I could teach introductory courses in most areas of technical, theoretical, and practical computer science. I do have some experience with theory courses (covering topics like logics, proof systems, computability, computational complexity, graph theory), but giving courses on programming and data structure and algorithms would probably be the most fun for me in teaching undergraduates.

In recent years, I also started a major initiative to increase interest in science and technology among young people. To carry this effort, I founded a non-profit organization, called *The Cool Science Institute* or *TCSI* (www.tcsi.de), which initiates robot building labs in high schools. I have designed and executed courses teaching teachers how to organize and teach robot building labs in schools and provided teaching material for them. Experience shows that these robot building labs are well-received and that we can interest the best students to consider computer science and engineering for their later careers. It would be fun to exploit these positive experiences elsewhere and start similar activities.

3.3 Teaching Experience

WT = winter term, ST = summer term, (m+n/p) = weekly hours of lectures + lab / credit points

3.3.1 Courses and Associated Labs

University of Applied Sciences Bonn-Rhein-Sieg:

ST 2005   *Middleware for Robotics and Embedded Systems* (in English), course (2+2/6).

University of Ulm:

ST 2004   *Autonomous Mobile Systems*, course (2+2/6).
WT 2003/2004   *Computational Economics*, course (2+2/6).
ST 2003   *Autonomous Mobile Systems*, course (2+2/6), ISI summer compact course.
ST 2003   *Autonomous Mobile Systems*, course (2+2/6).
WT 2002/2003   *Autonomous Mobile Systems II*, course (2+2/6).
ST 2002   *Autonomous Mobile Systems I*, course (3+1/6).
WT 2001/2002   *Multiagent and Multirobot Systems*, course (3+1/6).
ST 2001   *Robotics I: Technical Foundations and Robot Control Architectures*, course (3+1/6).
WT 2000/2001   *Theoretical Computer Science I*, lab class (2/4) (with G. Palm).
ST 2000   *Robotics II*, course (2+2/6).
WT 1999/2000   *Robotics I*, course (2+2/6).
WT 1998/1999   *Artificial Life*, course (in Englisch) (2+2/6).
ST 1998   *Robotics II: Representation, Planning and Learning*, course (2+2/6).
WT 1997/1998   *Robotics I: Technical Foundations and Robot Control Architectures*, course (2/4).
ST 1997   *Spatial and Temporal Representations in Robotics*, course (2/4).
WT 1996/1997   *Control Architectures for Autonomous Mobile Robots*, course (2/4).
WT 1995/1996   *Theoretical Computer Science I*, lab class (2/4) (with G. Palm).

Grundig Academy, Nuremberg:

WT 1985/1986   *Introduction to EDP*, 22 days of 7 hours each of lectures.
WT 1985/1986   *Software Engineering*, 10 days of 7 hours each of lectures.

3.3.2 Seminars

University of Ulm   each (2/4)

ST 2004   *Neural Networks in Robotics*, seminar, ISI summer compact course.
ST 2001   *Edutainment Robotics*, seminar, weekend seminar at Fabri-Institute in Blaubeuren.
WT 2000/2001   *Neuroinformatics*, seminar (with G. Palm, H. Neumann, F. Schwenker, A. Strey).
WT 1999/2000   *Neuroinformatics*, seminar (with G. Palm, F. Schwenker, A. Strey).
WT 1998/1999   *RoboCup: Theory and Practice of Autonomous Robotic Soccer Players*, seminar (with S. Biundo-Stephan, H. Neumann, F. von Henke, G. Baratoff, J. Rintanen), weekend seminar at Fabri-Institute in Blaubeuren.
WT 1997/1998   *Recent Topics in Robotics*, seminar (with G. Palm, F. von Henke, J. Rintanen).
ST 1997   *Neural Networks and Genetic Algorithms*, seminar (with A. Strey, A. Küchler, B. Talle, A. Wichert).
WT 1996/1997   *Neuroinformatics*, seminar (with G. Palm, H. Neumann, F. Schwenker, A. Strey).
WT 1996/1997   *Robotics*, seminar (with G. Palm, H. Neumann, E. Littmann).
WT 1995/1996   *Integration of Connectionist and Symbolic Information Processing*, seminar (with K. Schill, A. Küchler).

WT 1995/1996	*Autonomous Vehicles*, seminar (with B. Nebel, E. Littmann, A. Hemprich).

University of Erlangen   each (2/4)

ST 1993	*Reasoning About Change*, seminar, with invited talks by external speakers, (with C. Beckstein).
ST 1992	*Multiagent Planning and CSCW*, with invited talks by external speakers, weekend seminar in Aufseß, (with C. Beckstein, E. Lutz, and G. Görz).
ST 1991	*Distributed Artificial Intelligence*, with invited talks by external speakers, weekend seminar in Aufseß, (with C. Beckstein and E. Lutz).
ST 1990	*Knowledge Representation*, seminar (with R. Gastner).

Technical University of Berlin   (2/4)

WT 1988/1989	*Distributed Artificial Intelligence*, seminar (with W. Tank and M. Hein).

3.3.3 Practice Lab Courses

University of Applied Sciences Bonn-Rhein-Sieg:

ST 2005	*Agile Software Team Techniques* (in English), course (2/4).

University of Ulm (8 credit points each)

ST 2004	*Mobile Robots and Embedded Systems*, ISI summer compact course.
WT 2003/2004	*Adaptive Autonomous Agents*
ST 2003	*Embedded Systems and Modular Robotics* (with J. Kaiser).
WT 2002/2003	*Multirobot Teams*
ST 2002	*Autonomous Mobile Robots* (with J. Kaiser).
WT 2001/2002	*Robotics*.
WT 2000/2001	*RoboCup*.
WT 1999/2000	*Robotics* (with S. Biundo-Stephan, F. von Henke, G. Palm, T. Liebig)
ST 1999	*Neuroinformatics* (with G. Palm, H. Neumann, F. Schwenker, A. Strey)
WT 1998/1999	*Autonomous Mobile Robots*.
ST 1998	*Autonomous Mobile Robots* (with G. Palm, F. von Henke, H. Rueß).
WT 1997/1998	*Robot Building Lab (RBL-98-UU)*: 6-day practical course and introduction to robotics for students and staff of University of Ulm, with 6-hour tutorial, extensive lab work (supervised by TAs and open daily 24 hours), and public robot competitions.
ST 1997	*Autonomous Mobile Robots* (with G. Palm, F. von Henke, H. Rueß).
ST 1996	*Autonomous Vehicles* (with G. Palm).
ST 1995	*Vehicles* (with G. Palm, E. Littmann).

University of Erlangen

ST 1994	*ROBOLAB-94*: 6-day practical course and introduction to robotics for students of University of Erlangen and FORWISS staff, with 4-hour tutorial, extensive lab work (supervised by TAs and open daily 24 hours), and public robot competitions.

3.3.4 Tutorials

10/2001	*Robot Building Lab*, 2-day course for high school teachers, Bayreuth.
12/2000	*Robot Building Laboratories*, 2-day course for high school teachers, Vöhringen.
05/1998	*Robot Building Laboratory*, tutorial for high school students from the Ulm area.
02/1998	*Robot Building Laboratory*, tutorial for students and staff of the University of Ulm.
03/1996	*Robot Building Laboratory*, tutorial, Spring School on Artificial Intelligence 1996 (KIFS-96), Günne am Möhnesee.

06/1995	*Robot Building Laboratory*, tutorial for students at FH Ravensburg-Weingarten. Teaching contract for 2-hour semester course.
03/1995	*Robot Building Laboratory*, tutorial, Spring School on Artificial Intelligence 1995 (KIFS-95), Günne am Möhnesee. (with Josef Schneeberger)
07/1994	*Robot Building Laboratory*, tutorial for *RBL-94*, National Conference on Artificial Intelligence (AAAI-94), Seattle, WA, USA. (with Josef Schneeberger)
05/1994	*Robot Building Laboratory*, tutorial, University of Erlangen and FORWISS. (with Josef Schneeberger)

3.3.5 Project Work, Study Theses, and Diploma Theses Advised

A project work is a small, abouth three months long project to be performed by students of University of Ulm. Approach and results must be documented in an accompanying thesis. Students may work in a group of two or three. The study theses were supervised at the University of Erlangen, where it is a somehwat larger project, roughly equivalent to two project works. A Diploma thesis is full-time six-month project to be done by each Diploma student after finishing his final diploma exams. It should demonstrate that the student is able to solve significantly large problems in computer science on his own. Enhancing the state of the art is not formally required, but often part of the project, especially if the Diploma thesis contributes to research projects.

[1] Klaus Uhl. Entwicklung und evaluation eines objektiven bewertungsverfahrens für slam-algorithmen. Masters thesis, University of Ulm, Neuroinformatics, 2005.

[2] Jonas Melchert. Vision-based motion estimation and object tracking in robocup. Master's thesis, University of Ulm, 2005.

[3] Jörg Sporer. Ease - economic agent simulation environment. Masters thesis, University of Ulm, Neuroinformatics, 2005.

[4] Florian Sterck. Action Arbitration for Behavior Hierarchies. Student project, University of Ulm, Neuroinformatics, 2004.

[5] Roland Reichle, Florian Sterk, and Simon Natterer. Sparrow-04: An autonomous mobile soccer robot. Student project, University of Ulm, 2004. (in German).

[6] Peter Schaeffer. Implementierung eines verteilten, ereignisgesteuerten Echtzeitsystems für Robotikanwendungen. Masters thesis, University of Ulm, Neuroinformatics, January 2003. (in German).

[7] Johannes Veser. Implementierung einer Microcontroller-Steuerung und eines CAN-basierten Publisher-Subscriber-Protokolls für ein Infrarot-Sensor-Array. Student project, University of Ulm, 2003. (in German).

[8] Björn Wiedersheim. Implementierung einer Microcontroller-Steuerung für die Detektion von Beschleunigungsereignissen mittels eines MEMS-basierten Beschleunigungsensors. Student project, University of Ulm, 2003. (in German).

[9] Marcus Lauer. Self-Organizing Spatial Distribution Patterns in Robot Soccer. Student project, University of Ulm, Neuroinformatics, 2003. (in German).

[10] Philipp Baer. Fault-Tolerant CORBA-Based Group Communication Services for Mobile Robots and Embedded Devices. Student project, University of Ulm, Neuroinformatics, 2003. (in German).

[11] Roland Reichle and Sebastian Przewoznik. Neural Learning of Dribbling Behaviors. Student project, University of Ulm, 2003. (in German).

[12] Klaus Uhl. A quadtree service for miro. Bachelor thesis, University of Ulm, Neuroinformatics, 2003. (in German).

[13] Marcello Carletti. Self-Localization with Self-Calibrating Omnidirectional Cameras. Master's thesis, University of Parma / University of Ulm / University of Genoa, July 2002. (in Italian).

[14] Kristijan Jelicic. Community Web Services for Non-Profit Organizations. Masters thesis, University of Ulm, Neuroinformatics, November 2002. (in German).

[15] Thomas Ketterle. Ein Programm zur Erstellung und Verwaltung von Umgebungsbeschreibungen für autonome mobile Roboter. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 2001. (in German).

[16] Guillem Pages Gassull. A User Interface Agent for Tele-Operating an Autonomous Mobile Robot. Master's thesis, University of Barcelona and University of Ulm, Neuroinformatics, June 2001.

[17] Hans Utz. Quo vadis? Robuste hierarchische Navigation für autonome mobile Roboter. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, October 2000. (in German).

[18] Marcus Ritter. Kamerabasierte Selbstlokalisierung autonomer mobiler Roboter. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, 2000. (in German).

[19] Peter Schaeffer. Entwicklung einer Controllerplatine für RoboCup-Roboter. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 2000. (in German).

[20] Thomas Ketterle and Hans Utz. Planungsmöglichkeiten auf einer Colored Kohonen Map. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 1999. (in German).

[21] John Donald and Niels Gura. Smartsoft Pioneer Server. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 1999. (in German).

[22] Udo Boysen. Simulation von Sensormodellen mit Neuronalen Netzen. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, August 1999. (in German).

[23] Hans Braxmeier, Heiko Folkerts, and Marcus Ritter. Empirische Evaluation des Pioneer-1 Roboters mit der PAI-Bibliothek. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 1998. (in German).

[24] Uli Blankenhorn. Automatische Spracherkennung für mobile Roboter. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, 1998. (in German).

[25] Moritz Wende. Visuelle Bewegungsinformation zur autonomen Roboternavigation. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, October 1997. (in German).

[26] Stefan Enderle. Realtime Sensor Fusion and Map-Building for a Mobile Robot. Masters thesis, University of Ulm, Neuroinformatics, June 1997.

[27] Volker Baier, Gerd Mayer, and Markus Müller. Autonome Mobile Vehikel: Integration symbolischer und sub-symbolischer Wegeplanung. Student project, University of Ulm, Neuroinformatics, Ulm, Germany, 1997. (in German).

[28] Stefan Calmbach. Die Neuronale Faltungsarchitektur – Erweiterung, Implementierung und empirische Evaluierung am Beispiel der Termersetzung. Masters thesis, University of Ulm, Neuroinformatics, Ulm, Germany, 1996.

[29] Joachim Klausner. The Knowledge Mining Center: Ein werkzeug zur wissensakquisition. Study thesis, University of Erlangen, Erlangen, Germany, 1994. (in German).

[30] Christoph Dotzel. Über die Verwaltung von Plänen in Multi-Agenten-Welten. Masters thesis, University of Erlangen, Erlangen, Germany, June 1994. (in German).

[31] Rolf Reinema. PEDE–Lab: Aufbau und Entwicklung einer Experimentierumgebung für Multi-Agenten-Systeme. Masters thesis, University of Erlangen, Erlangen, Germany, March 1993. (in German).

[32] Robert Fuhge. Verteilte ATMS-basierte Plangenerierung. Study thesis, University of Erlangen, Erlangen, Germany, July 1993. (in German).

[33] Martin Riederer. Just-in-Time-Beschaffungsprozesse in der Automobilproduktion als PEDE-Problem. Masters thesis, University of Erlangen, Erlangen, Germany, February 1993. in cooperation with Daimler-Benz AG, Werk Sindelfingen. (in German).

3.3.6 Dissertation Theses Co-Advised

[1] Stefan Sablatnög. *Region-Based Representation of Spatiotemporal Concepts*. Dissertation, University of Ulm, Neuroinformatics, Ulm, Germany, October 2001.

[2] Stefan Enderle. *Probabilistic Spatial Representations for Mapping and Self-Localization in Autonomous Mobile Robots*. Dissertation, University of Ulm, Neuroinformatics, Ulm, Germany, June 2001.

4 Scientific Interests

4.1 General Research Interests

My long-term, general research interests can be structured into three different categories:

- My *scientific interests* aim at the **understanding of complex systems and phenomena**, especially of complex behavior emerging from the interaction of many components. Two outstanding examples for such systems are the human brain and market-based economies. I am in particular interested in the principles and methods of formalizing, modelling, simulation, design, and control of such systems.

- My *engineering interests* focus on the **application of principles and methods**, which are derived from the study of complex systems, **to technical applications**. Robotics, manufacturing and logistics, and the Internet are fields providing highly interesting opportunities for such applications.

- My *economics and management interests* aim at the **application of principles and methods**, which are derived from the study of complex systems, **to management and economics**, in particular in the areas of modelling and (re)engineering business processes, corporate strategic planning, and learning and adaptation processes in large organizations.

Furthermore, I am generally interested in management of innovations and technology transfer.

4.2 Specific Research Interests

My past and current, more specific research activities can be grouped as follows:

- **Adaptive Autonomous Agents**, in particular neural and evolutionary learning methods and reinforcement learning in learning autonomous systems.
- **Autonomous Mobile Robots**, in particular robot control architectures, behavior-based control, and massively parallel sensorimotor systems.
- **Edutainment Robotics**, in particular the use of robots in education and teaching as well as for leisure and entertainment.
- **Neurosymbolic Integration**, in particular the integration of neural, geometric, and relational approaches for spatial cognition.
- **Softbots** and **Multiagent Systems**, in particular for modelling, planning, and scheduling of complex activities, like business processes.
- **Cooperative Systems**, especially spatiotemporal aspects of cooperation and hybrid cooperative systems consisting of distributed technical systems and humans.
- **Software Development**, **Middleware**, and **Experimental Testbeds** for complex distributed systems and embedded systems.

4.3 Adaptive Autonomous Agents

Agents are nowadays a widely used concept for structuring large, especially distributed and interactive application systems on a macroscopic level. A generally accepted definition of the notion of *agent* is not available and difficult to find. I am particularly interested in *autonomous agents*, and I use the definition of autonomous agent as an autonomously executing module, which tries to achieve a well-defined function, often acts on behalf of a human user, and can take decisions and execute actions autonomously after receiving external sensations (like sensor data, incoming messages, etc.). The construction and maintenance of autonomous agents, for example in robotics, is a time-consuming and costly process, in particular, if the application environment is dynamic. Therefore, adaptation and learning of autonomous agents are highly interesting research problems, which I want to tackle primarily with neural and evolutionary learning methods.

In our projects, we have repeatedly and successfully applied both supervised and unsupervised neural learning approaches. Our research focusses on the integration of such methods with symbolic information processing methods. Examples are hierarchical RBF networks (supervised) for object classification based on visual feature vectors and colored Kohonen networks (unsupervised) for the automatic extraction of symbolic region information from probabilistic grid maps. Of particular interest are reinforcement learning methods, which need only a qualitative feedback signal, instead of a precise and correct teacher signal, and can be easier applied in sensorimotor systems. In this area, we work on the improvement and extension of Q-Learning to problems with continuous state spaces and have developed methods for adaptive state space discretization.

Work elsewhere has shown that evolutionary learning approaches like genetic algorithms and genetic programming can often achieve good results after much shorter learning periods. However, the application of these methods in robotics is difficult and usually requires the use of simulation environments. In my future work, I would like to work more in this area and to investigate combinations of neural and evolutionary approaches and other hybrid learning methods.

4.4 Autonomous Mobile Robots

Mobile robots are often complex sensorimotor systems. Their programming and control is difficult and time-consuming, because both sensor processing and effector control pose realtime processing constraints. Effective and efficient architectures for robot control, which meet different system and user requirements, are therefore one of my prime research interests for some time. On the lower system levels, we follow a behavior-based control approach, which has proven to provide the necessary reactivity to unforeseen events.

A still more or less unsolved open problem is the integration of plan-oriented, deliberative components with behavior-based architectures. Most existing approaches to combine a symbolic AI planner with reactive, behavior-based plan execution suffer from severe practical limitations. However, if symbolic planning methods are able to generate reasonable solution candidates with acceptable computational effort, then the application of symbolic planning methods with a successive learning step could possibly shorten learning periods significantly.

An idea I follow up recently is the use of learning techniques for bottom-up learning of increasingly complex behavior hierarchies. This approach is investigated in particular by our RoboCup team and in the SPP-1125 project *Adaptivity and Learning in Teams of Cooperating Mobile Robots*, which is funded by DFG.

Another interest, which I could not follow so far for technical reasons, is in massively parallel sensorimotor systems, in particular, artificial muscles and learning their control. While currently used robotic systems usually have only a limited number of degrees of freedom, the degree of freedom is several orders of magnitude higher for artificial muscles. For this interest, I intent to build a simulation system for artificial muscles, that permits to implement and evaluate various learning techniques.

4.5 Edutainment Robotics

One of the most interesting application areas for autonomous mobile robots is edutainment, i.e. the use of robots in education and entertainment. Both uses pose problems that have seen little scientific research so far.

For education, robust and modular mobile robots for use in schools and universities are needed. Both hardware and software components of such robots must meet the age- and gender-specific needs of students. GUI-based and visual programming environments suited for use in schools are of special interest. Here, I would like to implement an agent-oriented programming approach based on Java.

In order to use mobile robots in entertainment and marketing, their capabilities to interact and communicate with humans must be significantly improved. Aside of speech processing, new methods for the recognition and

interpretation of mimics and gesture could be especially helpful to model emotional aspects of human-computer interaction. Interesting applications would be robots in shopping centers and car-free inner city zones.

4.6   Neurosymbolic Integration

The integration of subsymbolic, especially neural, and symbolic information processing methods is being researched intensively for a couple of years now. The breadth of the work in this area is enormous, and few results can be generalized. Already during the conception of the SFB 527 project, we suggested that research on neurosymbolic integration on a very general, abstract level is less promising. We decided to concentrate on a specific scenario and to integrate neural, geometric, and relational representations for spatial knowledge. This research resulted in the development of the hybrid spatial representation architecture, DYNAMO, which has produced very promising results, two successfully completed dissertations, and is successfully used on our robot.

4.7   Softbots and Multiagent Systems

Multiagent systems were one of my major research interests already in the very early nineties, and I successfully applied them to model complex systems. Because of my focus on autonomous mobile robots later on, multiagent systems were less relevant for a while. Our participation in RoboCup made the representation and modelling of the behavior of other agents again more important. Unlike in the past, I now mainly consider multiagent systems consisting of *autonomous* agents. In the future, I intent to focus on the investigation of the mutual relationships between autonomy and adaptivity, and between cooperation and competition. This research is also highly relevant for many Internet applications.

4.8   Cooperative Systems

In the area of cooperative systems I am in particular interested in scenarios where several technical subsystems (software agents, autonomous robots, machines) are required to cooperate with human users. The seemingly conflicting goals of cooperation desired on a overall system level, autonomy necessary for single agents, and the level of system security and integrity to be guaranteed pose numerous open problems and define opportunities for research. Aspects of spatially distributed cooperative systems have been rarely investigated so far. My experience and work on spatial cognition and neurosymbolic integration in robotics open good opportunities in this field.

4.9   Software Development, Middleware and Testbeds

A commonality of all previously mentioned areas of research is that usually very complex software systems are used. Their development and maintenance is often very tedious, time-consuming, and error-prone. Therefore, the development of methods and tools for improving the software development process in these areas is of central interest. We designed and implemented *Miro*, an object-oriented, CORBA-based middleware for developing software for mobile robots, sensorimotor systems, and similar embedded systems. Miro meets modern software engineering standards and is freely available. Possible extensions of Miro in the future include the integration of the neural language EpsiloNN, or probabilistic language extensions, and the construction of graphical specification tools for such language extensions.

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5.10 Intellectual Property Rights

[1] Stefan Enderle, Gerhard K. Kraetzschmar, Stefan Sablatnög, and Steffen Simon. Dreidimensionales Bauelement und Baukastensystemen zum Zusammenbau von Konstruktions- und Spielmodellen. Small Patent (Gebrauchmuster) No. 201 00 782.7, German Patent and Trademark Office (DPMA), Munich, Germany, April 2001. (in German).

6 Agenda

6.1 Research Projects Under Review

- **Adaptivity and Learning in Teams of Cooperating Mobile Robots**, proposal within DFG Focal Point Program SPP-1125 *Cooperating Teams of Mobile Robots in Dynamic Environments*, 3rd funding period. Project management (jointly with Prof. Palm). Already positively reviewed; awaiting funding letter. Expected funding around 170.000 Euros.
- **Roberta Goes EU**, proposal by Fraunhofer AIS for funding of Specific Support Action within EU FP 6 Science and Society. Already positively evaluated and in contract negotiation phase. Project management and principal investigator. Expected funding about 670.000 Euros.
- **ProfiBot**, proposal submitted to BMBF by Fraunhofer AIS for funding development of a modular experimentation system for mechatronics education. Applied funding about 1.200.000 Euros.

6.2 Ongoing Advisory Work

[1] Guillem Pages Gassull. *Spatiotemporal Structures for Autonomous Mobile Robots*. Dissertation, University of Ulm, Neuroinformatics, Ulm, Gerrmany, 2005. (in preparation).

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6.3 Publications in Press

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