

Preface

Dear Conference Participants,

It is our great honour and pleasure to welcome you to Ilmenau on behalf of the organizers of the 55th International Scientific Colloquium (IWK).

The IWK looks back on fifty five years of tradition in exchanging scientific ideas and bridging disciplines. In 2010, from September 13 to 17, the central theme is "Crossing Borders within the ABC - Automation, Biomedical Engineering and Computer Science".

The Colloquium's structure reflects the interdisciplinary title with 15 workshops and 215 talks.

The common denominator of all International Scientific Colloquiums in Ilmenau is the way the intersecting topics relate to aspects of computer science, engineering, biomedical science and other sciences, treating highly relevant topics in the multidisciplinary manner with the help of many and varied contributing scientists. This is in contrast to many other workshops or conferences, which concentrate on specific applications or subfields of science. The Colloquium series is unique in bringing together and promoting interaction between scientists from various backgrounds and from all over the world. In 2010 it is certain that the 55th International Scientific Colloquium will substantially contribute to the exchange of new ideas and new views in Automation, Biomedical Engineering and Computer Science.

We are very happy that this year many young scientists will contribute to the success of the IWK in various sessions. Young people are a major driving force in science with their fresh ideas and unconventional views. 2010 sees the start of what we hope will be a tradition of special sessions for young scientists.

Without the help of a large number of people the 55th International Scientific Colloquium would not have been possible. We would like to thank all contributors, all reviewers, all sponsors, and Prof. Detschew and his team for the wonderful preparation. Special thanks go to the organizing team of Mrs. Schneider.

With our welcome, we extend to you our good wishes — may you find stimulating conversations and valuable contacts and may your stay at Ilmenau University of Technology bring you an interesting time in our town and its delightful surroundings.



Professor Peter Scharff
Rector, Ilmenau University of Technology



Professor Jens Haueisen
Dean of the Faculty of Computer Science and Automation

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CONFERENCE PROGRAMME AT A GLANCE

55th Internationales Wissenschaftliches Kolloquium, 13 – 17 September 2010

Room Date	Audimax	129	201	202	204	211	010	011	012	013	210	131	117
Sunday, 12.09.10 5:00 p.m. – 9.00 p.m.	Foyer Humboldt Building: Registration in the Conference Office												
Monday, 13.09.10 8:00 a.m. – 4:00 p.m.	Foyer Humboldt Building: Registration in the Conference Office												
11:00 a.m. – 1:00 p.m.	Opening of the 55 th IWK (Plenary Session)												
1:30 p.m. – 4:30 p.m.		C2	A5.1	ABC 1	A6	B3	A2.1			A4.1			
4:30 p.m. – 7:00 p.m.	Foyer Humboldt Building: Welcome Reception for all speakers, participants and guests												
Tuesday, 14.09.10 9:00 a.m. – 12:00 noon		C4	A5.3	ABC 1	A6	B3	A2.2	A3.1	C7	A4.2			
1:30 p.m. – 4:30 p.m.		C4	A5.2	C3	A6	B3		A3.2	C7	A4.3			
8:00 p.m.	Ilmenau's Festival Hall: Academic Gala Concert												
Wednesday, 15.09.10 9:00 a.m. – 12:00 noon		C4				B2							
1:00 p.m. – 2:00 p.m.	Start from the Humboldt Building: Scientific guided tours (any one time)												
2:30 p.m. – 10.30 p.m.	Start from the Mensa (Refectory): Excursion to Erfurt (Capital of Thuringia), Organ Concert, Sightseeing tour during the historic town, afterwards Banquet in the Hotel "Tanne", Ilmenau												
Thursday, 16.09.10 9:00 a.m. – 12:00 noon				C5		B2							
1:30 p.m. – 4:30 p.m.				C5	C6	B2							
Friday, 17.09.10 9:00 a.m. – 12:00 noon		TKM- WS			C6								
Legend	Workshops of the 55 th IWK	Accompanying Programme of the 55 th IWK						Further Events / Workshops					

Internet-Cafe

Monday, 13.09.10, 10:15 a.m., Welcoming Address and Press Conference to the Plenary Lecturers of the 55th IWK. (by separate invitations)

Wardrobe

Conference Office

Registration

Organisation Ilmenau University of Technology
Conference Management / Conference Office
Mrs Andrea Schneider

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**Opening hours/
Registration**

Sunday, 12.09.10	5:00 p.m. – 9:00 p.m.
Monday, 13.09.10	8:00 a.m. – 4:00 p.m.
Tuesday, 14.09.10	8:00 a.m. – 8:00 p.m.
Wednesday, 15.09.10	8:00 a.m. – 1:00 p.m.
Thursday, 16.09.10	8:00 a.m. – 8:00 p.m.
Friday, 17.09.10	8:00 a.m. – 1:00 p.m.

General Information

Catering

Coffee break refreshments

At the colloquium, refreshments will be offered during the coffee breaks in the foyer of the conference building.

Meals and Refreshments

All participants may take advantage of the catering service in the Mensa (refectory) of the university. You can get there within a few walking minutes from the conference building.

The cafeteria "MINI" at the Humboldt Building also provides meals and beverages on a limited scale.

Conference Programme

Press Conference

**Monday, 13.09.10,
10:15 a.m.**

The Rector of the TU Ilmenau, Professor Peter Scharff, and the Dean of the Faculty of Computer Science and Automation, Professor Jens Hauelsen welcome the Plenary Lecturers.
(by separate invitation)

Location

Humboldt Building/ Room 131

Conference Programme

Opening Ceremony

13.09.10, 11:00 a.m./ Audimax	Musical opening by the Members of the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau
Moderation	Professor Vesselin Detschew, Head of Organization
11:05 a.m.	The participants will be welcomed by - Professor Peter Scharff Rector, Ilmenau University of Technology - Professor Jens Haueisen Dean of the Faculty of Computer Science and Automation - Jakob von Weizsäcker Representative of the Thuringian Ministry of Economy, Technology and Labour
11:25 a.m.	Plenary Lecture Professor Shoogo Ueno, Kyushu University, Teikyo University and University of Tokyo, Japan “Biomagnetics: An Interdisciplinary Field Where Magnetism, Biology, and Medicine Overlap”
12:10 p.m.	Plenary Lecture Professor Jürgen Beyerer, Karlsruhe Institute of Technology KIT and Fraunhofer-Institute of Optronics, System Technologies and Image Exploitation IOSB, Karlsruhe „Variable Image Acquisition and Image Fusion“
1:00 p.m.	End of the Opening Ceremony

Conference Programme

Welcome Reception

13.09.10,
4:30 p.m. – 7:00 p.m.

All lecturers, participants, guests and companies are kindly welcome to the Reception.

Weather permitting, the welcome reception will be given on the square in front of the Humboldt Building. Otherwise, our guests are kindly asked to go inside.

The Reception will be held immediately after the Opening Ceremony.

Enjoy yourselves!



Music provided by: Swinging Fun

ABC1 Ambient Assistant Living – AAL-project WEITBLICK

– mile stone

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 202

Chairman: F. Roß (DE-Ilmenau)

1:30 p.m.	St. Lutherdt, K. Lienert, C. Stiller, F. Roß, Ch. Ament, H. Witte (DE-Ilmenau)
<p>WEITBLICK – An Assistance System for Elderly in User’s Appreciation</p> <p>To successfully develop an assistance system for a certain user group, it is important to identify the user's needs at an early stage of development. This is the important the more heterogeneous the user group is composed of. An example for this is the development process of the public-funded project WEITBLICK. This paper describes the current activities of the project to accompany the technical development. A requirements analysis, divided in three consecutive parts, was held at the very beginning of the project. It comprehended of expert interviews, focus groups and a comprehensive questionnaire. Resulting of these analyses the requirements of system components, required services and offers for the users and design requirements for hard- and software components were derived and given to the project partners. Jointly with this stage of development a demonstrator system was designed. With this it is feasible to test the user’s experience and understanding of menus, navigational structures and different input strategies. To support the users it was realized that a special input device is congruently designed to the graphic user interface. The input device consists of four colors which are the same the users need to use for navigation thru the GUI. To evaluate the results of the whole development process some scenarios will be used which also were set up with results of the beginning analyses. For these evaluations were defined three different groups of users: “younger”, “middle” and “very old” seniors because the analyses showed that there are differences between them in matters of their expectance of the system and its components. Also in matters of desired services, problems in use of pushbutton-based input devices and additional system components for monitoring of vital functions these groups are differing. The survey had shown the general interest of potential users to have and use such a system, but it will not only up to the user-friendly developed system but also up to a user-friendly concept of operating. Most of the potential users will spend no or less money to have such a system what is a high requirement to future management activities.</p>	

A Hybrid Recommender System for Information Brokering within WEITBLICK

With this paper the concept for individualized information brokering within WEITBLICK, an assistance system developed in a public founded research project, is introduced. The aim of the project WEITBLICK is to enable elderly people to a longer self-fulfilling life in their own homes by providing information about health, care and leisure activities over one comprehensive source. To filter the large amount of information and services to the needs of the user, a recommender system will be used. The design of the recommender system follows a three tier structure: The first tier is used to generate candidate services depending on the user's wish, which is reproduced from the settings provided by the user over the UI. The wish might contain constraints about content, time and location, but also about personal interests and physical capabilities. With this approach it is possible to offer a wide range of different services while still be able to present only recommendations currently adequate to the user's needs. The second tier contains different single recommender system, which generate predictions of how useful the candidates are. Here several different approaches can be implemented in parallel, for instance demographic filtering, content-based filtering and collaborative filtering. All of these approaches are known to work well in different situations, while not working that well when sufficient information is lacking. Furthermore the generation of recommendations based on geographic relations seems to be promising for the described task, so according enhancements to the aforementioned approaches will also be utilized. Finally, in the third layer, the results of the recommender systems from the second layer are combined into a single prediction of the candidate's usefulness. Here, different metrics for the quality of the available data about the user and the candidates can be used to weight the results of the single recommender systems. Thereby insufficiencies from the one or the other single recommender can be counterbalanced.

Design and Development of a Communication Middleware for Ambient Assisted Living Environments

The changing demography requires new kinds of support for elderly people. Technical assistance systems could allow (aged) people to stay longer in well-known neighbourhoods. While utilizing familiar media usage habits, the acceptance rate of a technical assistance system will be increased. Therefore, as many as possible potential communication methods between users and the assistance system are required. This paper describes an assistance system which get designed, developed and deployed within the research project called "WEITBLICK". A Server represents the central system component with data and information management. Here, information about user abilities, their usage history and offered service descriptions are stored in different profiles. This key module is linked with a recommender system, which continuously analyses the present data and link services to users and vice versa according to the profiles and abilities. Prospective users should be able to access the assistance system through technical devices or "human interfaces" like e.g. a call-centre agent. A communication middleware, located between server and clients, which will be discussed in this paper, has the aim to supplying a homogeneous communication interface in a heterogeneous infrastructure. So it's possible to utilise a wide range of different user device and many different communication technologies like cellular (2G/3G), DSL or broadcast media (DVB, DAB). Each communication technology has its unique properties. A communication middleware is helping to simplify assistance system design, especially when a consistent message exchange over many different communication technologies should occur. While designing such a communication middleware the following goals should be considered: - Providing a flexible and uniform communication infrastructure. - Smart selecting of appropriate communication technology for each communication session. - Communication technologies should be interchangeable and independent (as far as possible). The communication middleware implementation is based on JMS (Java Message Service) and it is scheduled to be done by the end of this year. The paper will further describe general challenges and it will show the approaches and development concepts which gets utilized.

2:30 p.m.	M. Oswald (DE-Erfurt)
<p>WEITBLICK – An Information Based Server Platform for AAL-services</p> <p>In the project WEITBLICK Kirchhoff Datensysteme Services concentrates on the research and development of an information based server platform for mediation social services, social contacts and technical assistance functions.</p> <p>Central functions such as data collection, data delivery, the communication interfaces, and self-management of the system are the basic modules of this platform. Any content functions can be integrated by using these basic modules. Defined processes allow interaction with each other function module and with the user. The primary visualization and communication is done via a generic web interface for different types of content, user groups and interface devices. These universal interfaces allow the use of functions and contents by any device that is equipped with web browser functionality. This allows maximum mobility.</p> <p>Developing the server platform attention will be paid to independence from the operating system and from the SQL database type. This allows optimal adaptation to changing environments and performance demands. Intrinsic safety of the platform by controlling the built-in function modules and data security by tampering protection and access protection is automatically provided by the designed system. This is done via a complex set of rules, the compliance of which is monitored by the basic components. These and other measures are supposed to ensure safe and continuous operation as well as compliance with the legal requirements.</p> <p>At the end of the project KDS will take over the hosting of the platform and the further commercialization.</p>	
2:50 – 3:10 p.m. Coffee break	
3:10 p.m.	
Demonstrations of the project WEITBLICK	
3:30 p.m.	
Demonstrations of the project WEITBLICK	
End of Lecture Session	

**A2.1 Modelling and Optimisation of Water Resources
Management Systems**
Time: Monday, 13.09.2010
Location: Humboldt-Building, Lecture Room 010
Chairman: H. Puta (DE-Ilmenau)

1:30 p.m.	Th. Ludwig, D. Gaida, P. Kern, M. Bongards (DE-Köln)
<p>Development of a Simulation Model for Hollow-Fiber and Flat Sheet Membrane Wastewater Treatment Plants</p> <p>INTRODUCTION The innovative technology of membrane wastewater treatment plants (MWWTPs) shows numerous advantages compared to classical purification techniques. Key for its commercial success is the reduction of energy consumption, enabled by the optimization of filtration by using a dynamic simulation model. This paper is focused on the development of a robust and flexible membrane bioreactor simulation model with submerged flat sheet or hollow-fibre modules, which is developed in Matlab [1] as part of a research project, funded by the Ministry of the Environment and Conservation, Agriculture and Consumer Protection of the German State of North Rhine-Westphalia. Model calibration is based on standard parameters often measured on MWWTPs, which enables the practical utilisability. Furthermore, the model can be combined with Activated Sludge Models [2]. The simulation model is of outstanding quality by its degree of practical usability.</p> <p>THE DYNAMIC SIMULATION MODEL The developed model simulates the dynamic change of membrane-permeability depending on process factors as total suspended solids (TSS), flow and transmembrane pressure. The permeate flux is calculated using Darcy's law, which relates the total resistance to the permeate flow using the "resistance-in-series-model" introduced by Choi [3]. The most significant factors for the modelling of Darcy's law is the TSS and the temperature of the membrane bioreactor, the age of the membrane, the crossflow aeration, the amount of water flow and the general chemical cleaning period as well as the length of the filtration and relaxation time. The simulation model is calibrated and validated successfully for the flat sheet full-scale municipal membrane WWTP at Seelscheid.</p> <p>REFERENCES [1] Mathworks, MATLAB and Simulink for Technical Computing. Available: http://www.mathworks.com (2010, Feb. 13). [2] M. Henze, W. Gujer, T. Mino, and L. van Loosedrecht, Activated sludge models ASM1, ASM2, ASM2d and ASM3. IWA Scientific and technical report no. 9. London: IWA Publishing, 2000. [3] S.-W. Choi, J.-Y. Yoon, S. Haam, J.-K. Jung, J.-H. Kim, and W.-S. Kim, "Modeling of the Permeate Flux during Microfiltration of BSA-Adsorbed Microspheres in a Stirred Cell," Journal of Colloid and Interface Science, vol. 228, no. 2, pp. 270–278, 2000.</p>	
1:50 p.m.	B. Scharaw, St. Dietze (DE-Ilmenau)
<p>Model Supported Design and Operation of a Wastewater Treatment Pilot Plant</p> <p>Wastewater treatment plants (WWTPs) are actually designed and in a very static way. They are designed for an assumed maximum load and hard limits according the water quality of at their effluent. Their operation parameter often are not changed much form the design parameters. In reality the loads at the inlet of the WWTP are changing hourly and may also change in their average over a longer period of time. Also the ecological needs for the</p>	

water quality at the effluent may change over the time. During a project on integrated water resource management (IWRM), Fraunhofer AST analyzed the WWTP of the City of Darkhan in Mongolia according to its design and operation. To support this analysis a mathematical model of the WWTP has been developed. Unfortunately the analysis showed it is preferable to build a new WWTP over changing the old one. Therefore, for a second stage of the project a pilot plant of a new WWTP will be built. The new WWTP will be of a sequencing batch reactor type. The planning and test operation will be supported by model based simulations for better integrating the dynamic nature of the processes into the design and operation procedure. Current status and future plans of these activities will be shown.

2:10 p.m. | A. Gnauck, J. D. A. Feugo (DE-Cottbus)

Time Scale Analysis of Water Quality Data

A sustainable management of water resources is very important for the survival of humans. Most of the signals from water resources are non stationary in their time structures. In this paper, water quality signals monitored in a freshwater ecosystem were investigated by classical and modern time series analysis methods. The classical methods revealed the presence of trends and long memories in the signals. The modern method revealed the presence of long-term cycling processes rather than linear trends in the signals which could not be detected by the classical methods. Investigation of long-term water quality signals (water temperature, dissolved oxygen, chlorophyll-a) by these methods was found necessary. In order to effectively assess the state of a freshwater body and develop an understanding of the interrelationship between the components for sustainable management, freshwater quality data collected by monitoring programs is extremely important. Extracting process information from the signals by classical methods usually requires modelling by the removal of the non-stationary and then fitting a stationary stochastic model. Information can be extracted by means of time series techniques like trend analysis, Fourier analysis, or wavelet analysis. In this paper, records of water temperature, dissolved oxygen and chlorophyll-a (algal biomass) from the Lower Havel River at the Potsdam monitoring station will be considered and analysed. The analysis will first consist of detecting general tendencies in the data set by means of the cumulative sum method. As a result, a change in the mean value of the signals across time is more pronounced in the chemical indicator as compared to the physical and biological ones.

Finally, wavelet decomposition will be applied to water quality signals so as to investigate their behaviour at different time scale as well as their long-term dynamics. The wavelet decomposition was applied to the water temperature, dissolved oxygen content and algal biomass signals. The original signals show the presence of yearly cycles. When the wavelet approach is used to decompose it till level eight, it is observed that longer cycles were actually hidden within the yearly cycles. When the water temperature signal is further decomposed to level nine, it reveals an approximately three year cycle. The approximations from wavelet decompositions of dissolved oxygen and chlorophyll-a till level 10 shows longer cycles which were not visible are progressively revealed. These levels represent a time scale of 4, 8 and 16 months respectively. An outcome from the final discussion of results is that there is a necessity for investigating the driving forces behind these observed long-term cycling at higher time scales as well as an investigation of the signals over longer periods of time.

2:30 p.m.	St. Röhl, S. Hopfgarten, P. Li (DE-Ilmenau)
<p>Groundwater Modelling within an Integrated Water Resources Management</p> <p>Groundwater is the only source for clean drinking water, but in many regions water resources are limited and in danger of pollution. Faced with this, management strategies are necessary to deal with valuable rare groundwater resources. Water models are used to evaluate resources and calculate management plans. The groundwater system is connected to other environmental systems and thus a global consideration has to be taken into account. The interdisciplinary approach of integrated water resources management (IWRM) considers the whole water cycle by modeling the different environmental subsystems like climate, hydrology, land use, ecology, groundwater, drinking water, and waste water. The complex structured system impacts the groundwater resources and must be considered for establishing management strategies. The groundwater system is implemented by modeling the governing equation of groundwater flow, describing the relation between groundwater level, flow and the hydro-geological parameter of the aquifer. The complex partial differential equation is solved with numerical standard methods, e.g. finite differences. For the solution as well as for the simulation initial and boundary conditions are necessary. The latter ones are defined as inputs and outputs of the groundwater system for the interaction with the other subsystems. First the model was used for analysis of the available water resources. For model predictive analysis and calculation of management strategies within the IWRM global scenarios were defined. Therefore the primary driver climate, economy, demography, and technical development were evaluated for their impact to the subsystems and secondary driver for each subsystem were derived. Related to groundwater these driving forces lead to sub-scenarios for water availability, water use, and demand, which were used to simulate the groundwater model within the IWRM. The practical implementation of the groundwater system within an IWRM will be explained for an arid region in Central Asia, where the BMBF research project MoMo was realized. The several steps of data acquisition, preparation, modeling, simulation, and calculation of sustainable management strategies within the global concept of IWRM are illustrated and results will be presented in this paper.</p>	
<p>2:50 – 3:10 p.m. Coffee break</p>	
3:10 p.m.	H. Willmitzer (DE-Erfurt)
<p>The completion of the dam Leibis/Lichte - The Use of Natural Processes and of Engineering Potentials for the Supply of High Value Drinking Water</p> <p>With the test of the full storage capacity of the dam Leibis/Lichte in 2010 a sure and high value drinking water supply for East-Thuringia has been finished. Considerable technical equipment and a comparable big water volume allow a specific control to the whole ecosystem in the reservoir and also in the underflow. The fast availability of physical, chemical and biological data allow the development of long time control strategies and also operative control concepts, respectively. The support of natural processes within the water is of high importance for a high level of water quality for drinking water supply. To control already the raw water resources is a sure way to reduce risks, caused by contamination or</p>	

climate conditioned events and consequently, to minimize also the effort for water treatment. First results since the dam up in 2005 let us realize that this broad discussed decision to complete the dam system has been the right decision.

End of Lecture Session

A4.1 Model-Based Process Optimisation and Control

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 013

Chairman: Prof. P. Li (DE-Ilmenau)

1:30 p.m.	H. Große-Löscher (DE-Ilmenau)
<p>Particle Swarm Intelligence: A Particle Swarm Optimizer with Enhanced Global Search Qualities and Guaranteed Convergence</p> <p>A new particle swarm optimizer is presented. The paradigm of particle swarm optimization - PSO - was published in 1995 by Russell Eberhart, an electrical engineer and James Kennedy, a social psychologist. This relatively young algorithm is related to swarm intelligence and evolutionary computation. Originally intended as a graphical simulation for the choreography and the social milieu of a bird flock, the originators realized the potential of this method to optimize continuous nonlinear functions. Particle swarm optimization is a meta-heuristic that proved to be very simple, robust and efficient. Particles are potential solutions of the function to be optimized. Cognitive and social components are attracting the particles while moving through the search space with a direction-dependent velocity. The algorithm is not limited regarding dimensionality or complexity of the optimization task. In addition to a basic introduction to particle swarm optimization, the performance of the algorithm in a static and three different dynamic environments is graphically demonstrated by a synthetically generated 2D test case illustrated by picture sequences and animations. The implementation of a refined constriction coefficient strategy influencing the particles' velocities led to a significant improvement in global search ability and a feasibility to guarantee final convergence, softening the original swarm characteristics. A comparison to the canonical PSO and a later introduced improved version is conducted. Furthermore, drawbacks of the conception for static operation applied to dynamic tasks, such as a phenomenon called 'linear collapse' are highlighted. Finally, the application of PSO to a static engineering problem with 361 parameters is described.</p>	
1:50 p.m.	M. Ritzmann, M. Bischoff, M. Golz, R. Böse (DE-Schmalkalden)
<p>A new Methodology for Optimization of the Geometric Highway Design Process</p> <p>This paper concerns the interactive 3D alignment and visualization of roadways as part of a new methodology for the highway geometric design process. A basic concept of the step of pre-planning is presented based on an alternative but simple interpolation model to circumvent the disadvantages of conventional 2D pre-planning. It is shown that quality management of the geometric design process is supported with regard to several criteria of safety, economy and aesthetics. Optimization in terms of safety takes into consideration that there are complex relations between the road, the vehicle and also the driver. Several aspects of these relations are tested and validated during driving simulation which is supported optimally by 3D design proposed. A new work-place is proposed in order to integrate driving simulation into the design process without requiring much effort from engineers. Finally, the new methodology is compared to the conventional one. For this commercial tools as well as subjective ratings of long-standing experts in road design are considered.</p>	

2:10 p.m.	M. Schulz (DE-Ilmenau)
<p>Optimized Maintenance and Logistic Process</p> <p>Model-based design using executable models has the potential to increase system design efficiency and accuracy significantly. In our department we work on an industrial application which covers system design issues in the area of avionics and airline operation, especially taking into account maintenance and logistics operations and their impact on fleet availability. In this paper is present an optimized maintenance and logistic process. Such a complex process needs to be modeled on a very abstract level of detail in the early phases of design, and undergoes a stepwise refinement throughout the further development. Executability of a model ensures that the model is a behavioral specification, and allows simulation runs for a performance evaluation of process alternatives. Decisions can thus be made with more confidence. We use the software tool MLDesigner in the paper, which is capable of modeling an evaluating hierarchical multi-domain models of complex processes. Different models of computation for submodels can be mixed, and an extensive library of predefined modules is available. Here is present parts of an abstract maintenance and logistic process model from an ongoing project, which is used to evaluate, among others, resource availabilities.</p>	
2:30 p.m.	K. Treichel (DE-Ilmenau), J. Jouffroy (DK-Sønderborg)
<p>Real-time sail and heading optimization for a surface sailing vessel by extremum seeking control</p> <p>Autonomous sailing vehicles like sailboat- or the so-called landyacht-robots are relatively new amongst other fully automated vehicles such as autonomous aerial, marine, submarine or road vehicles. However, in comparison sailing vehicles have a great potential due to their clean, nonpolluting means of propulsion – the wind, also representing a challenge in automation and control. A concern of most sailors is to optimize the longitudinal velocity or surge along a specific heading by trimming the sail in the best possible way, as well as maximizing the so-called velocity made good (VMG). For that purpose we develop a simplified mathematical model representing the main elements of the behavior of sailing vessels as a basis for simulation and controller design. For adaptive real-time optimization of the sail and heading angle we then apply Extremum Seeking Control (which is a gradient based control law that drives the output of a linear or nonlinear system to its extremum) as an approach to maximize the longitudinal velocity and the VMG respectively. The basic idea behind extremum seeking and “how it works” is presented, as well as a simulation study on noise, convergence and stability issues.</p>	
2:50 – 3:10 p.m. Coffee break	
3:10 p.m.	A. Bulgakov, A. Pruglov (RU-Nowotscherkassk)
<p>Mobile Flexible Automatized Producing Line for Manufacturing of Elements of Prefabricated Wooden Houses</p> <p>Mobile Systems Principles of organization, optimization and automatization of construction processes are analyzed in the article. The functional scheme of mobile flexible automatized</p>	

producing line for manufacturing of elements of prefabricated wooden houses is proposed. Analysis of economic effectiveness and competitiveness of the line is realized. Design and development of automated manufacturing and of the flexible automatized line for manufacturing of elements of prefabricated wooden houses in particular is a complex problem. Having been studied peculiarities of the construction of panel houses it is proposed to divide the technological process of manufacturing of sheet walls and other prefabricated elements into six technological sections. One should mention that the sections are located specifically: the outgoing production of one section is the incoming production of the next one. The technological process must be organized in such a way that at the point of entry logs are loaded and the finished construction elements and panels come off the last section. As a result of the realized analysis such factors as a positive economic effect of the introduction of the line into the sphere of construction activities (reduction of the cost per 1 m² of the floor) and improvement of the quality of prefabricated wooden houses due to the complete robotization of technological processes were revealed.

3:30 p.m. | T. Stolze, K.-D. Kramer (DE-Wernigerode), W. Fengler (DE-Ilmenau)

Tool-assisted Hardware Selection with "UBCS"

A correct decision for selecting a certain system, based on well-founded information, is essential for the development of a new product and its success on the market. Especially small and mid-size companies only have no or very limited human and technical resources. In most cases, there is no chance to run complex and time-demanding tests with potential systems to prove the appropriateness for the product. Therefore, a system for this use case, the support of a correct selection of a certain system, is currently developed at Harz University. This so-called "Universal Benchmark and Compare System", abbreviated "UBCS", supports developers when choosing suitable hardware. It contains various benchmark results of different target systems such as Microprocessors, Microcontrollers and Digital Signal Processors. Moreover, it also provides relevant information like technical specifications that are important for product development. "UBCS" is intended to suggest ideal hardware for a certain set of requirements. That is why developers are supported optimally during the mentioned phase and are able to select hardware in a future-proof and strategic planning way, while other information like future costs and availability are provided simultaneously. The paper focuses on "UBCS" from a point of view concentrating on the technical implementation, presents advantages resulting from using "UBCS" and provides a general view to present the project's development.

End of Lecture Session

A5.1 Mobile Systems – Navigation and Communication

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 201

Chairman: M. Lemmel (DE-Bremen)

1:30 p.m.	D. Jopp, M. Lemmel (DE-Bremen)
<p>Indoor Positioning on Industrial Facilities with an Accuracy of Measurement of $\pm 50\text{mm}$</p> <p>Within the joint project 'Indoor Positioning on industrial facilities with an accuracy of measurement of $\pm 50\text{mm}$', the partners BIMAQ and IAT on behalf of BCM and the engineering consultant Obergfell & Partner (IPO.Plan) developed an automatic and wireless acquisition of conveyor-technical factory layouts to be transferred into a CAD model of the facility. The project is funded by the German Federation of Industrial Research Associations (AiF) from the 01.07.2008 to the 31.12.2009. A system is developed to automatically capture the actual 3D-movements in conveyor-technical arrangements. An electronically or optically pursuable module, which follows the course of a conveyor, acquires defined parameters such as the conveyor height, role distances or inclinations using a new sensor system. The project aims at an exact and reliable detection within a covered facility. After studying the market of upcoming tracking solutions the 'Ubisense'-RTLS which uses ultra-wideband (UWB) radio was discovered as an appropriate solution and installed into a tentative production facility of about 900 m². This application is intrinsically more accurate than other radio technologies because of its resistance to signal distortions caused by the reflections that always occur in real-world deployments. The sensors use combined Angle-of-Arrival (AoA), Time-Difference-of-Arrival technology (TDoA). The associated software-package consists of two runtime environments and a development component. It is necessary to verify the included filter algorithms to respectively suit them to the according building. Though, accuracies of approximately 10 - 15 cm could be reached.</p>	
1:50 p.m.	J. Kessler, Ch. Gaudig, CH. Schroeter, H.-M. Groß (DE-Ilmenau)
<p>What is different? - Modeling the Changeability of the Environment</p> <p>In mobile robotics the task of finding an appropriate way to drive to a goal, following a person, or even to localize itself within a dynamic environment are still challenging tasks. To enable a mobile robot to interact well within the environment, the robot needs an internal representation of the environment, usually called a map. The problems of interaction with the environment arise by using an outdated representation (map) of the environment and releasing actions to an actual environment, e.g. by trying to drive through a blocked floor, a closed door or by trying to drive through moved pieces of furniture. This paper presents a new method of adapting the internal map in a consistent way by including new states of the environment and also retaining the old states of the environment. The basic idea of our approach is the inclusion of all sensor information at different "forgetting levels". We do so by assembling a stack of topological maps where for each node of the map sensor information is collected with a different update rate per stack slice. This way, we can model maps with long-term memory characteristic as well as with short-term characteristic and all in between. Our method also presents an approach how to create consistent environment information when the impression of a certain place was only partially observable and col-</p>	

lected at different points in time. The benefit of our approach is the representation of consistent expected observations at different levels of time-scale, so no mixtures of observations which are very unlikely to belong together are selected. All this information is represented in a consistent fashion to the mobile robot to improve self-localization and path planning in dynamic environments.

2:10 p.m. | Th. Glotzbach (PT-Lissabon), M. Schneider, P. Otto, Ch. Ament (DE-Ilmenau)

Bio-Inspired Adaptive Autonomy for Mobile Vehicle Teams: Results of the Research Project 'GREX'

The usage of the notation 'autonomy' in research on unmanned mobile systems often creates difficult situations. It is not intuitive to determine which abilities a vehicle must have to be called autonomous. The possibilities for the interaction of a human operator into the mission of an 'autonomous' vehicle is unclear. Especially for teams of unmanned systems, it is actually an antilogy to speak about 'cooperation' between 'single autonomous' systems. These problems can be solved by the interpretation of autonomy as a state in a spectrum which can be changed for each vehicle at all time. This concept is called Bio-Inspired Adaptive Autonomy. The nucleus of this paper is to give a concrete example of the usage of this principle during the research project 'GREX' which aimed to the development of a conceptual framework and middleware systems to coordinate a group of heterogeneous unmanned marine vehicles working in cooperation to achieve a well defined practical goal in an optimized manner. Within the GREX project, the participating researchers from eight institutions (both industry and universities) of five different countries with funding from the European Community were able to realize a group of unmanned marine vehicles, cooperating in different small scenarios. In this paper, we will describe the basic team abilities which were realized during this project. In doing so, it will get clear that these abilities required different control hierarchies, were different vehicles became the team leader for a certain period of time, while in other situations all vehicles operated on an equal level. These different architectures were necessary due to the special conditions in the maritime and underwater environment. The latter offers only limited communication and navigation abilities. We will show how the description and definitions of these architectures benefit from the Adaptive Autonomy concept which allows an evaluation and comparison between the different control structures and proof the importance of this concept. Finally, the paper will describe the practical results of the GREX project which were demonstrated during the Sea Trials at Sesimbra, Portugal, in the autumn of 2009.

2:30 p.m. | E. Einhorn, Ch. Schröter, H.-M. Groß (DE-Ilmenau)

Building 2D and 3D Adaptive-Resolution Occupancy Maps using Nd-Trees

In mobile robotics map building is an important basis for different navigational tasks. It provides a model of the environment that is essential for collision avoidance, path planning and localization. In the past, most approaches applied two dimensional occupancy grid maps which are built using sensors like laser range finders or sonar sensors that are able to obtain only two-dimensional information about the environment. Recently, different sen-

sors like time-of-flight cameras or 3D lasers are evolving which are able to obtain three-dimensional information about the local surroundings. Consequently, three dimensional representations are necessary to take full advantage of these sensors. In previous works, regular voxel representations and octrees have been proposed as a three dimensional alternative to 2D grid maps. However, all of these existing approaches have in common that they partition the environment into regular cells with a fixed resolution. The choice of the cell resolution is crucial. An improperly chosen resolution may lead to inconsistent maps or to maps with insufficient precision. In this paper we present a novel mapping technique that chooses the resolution of each cell adaptively depending on the measurements. If an additional measurement becomes available that conflicts with the current map estimate, i.e. the states of the existing occupancy cells, the measurement is either an outlier or the inconsistency is caused by a too coarse resolution of the map. In the latter case the affected cells are subdivided to increase the resolution. Simultaneously, neighboring cells with similar occupancy values are merged to reduce the spatial and computational complexity of the approach. Both splitting and merging of the cells is based on an information theoretic measure that we derive in this paper. Additionally, we introduce the Nd-Tree, a generalization of quadtrees and octrees that allows to subdivide any d-dimensional volume recursively with N^d children per node. Using this data structure our approach can be implemented in a very generic way and allows the creation of 2D, 3D and even higher dimensional maps using the same algorithm. Finally, we show results of our proposed method for 2D and 3D mapping using different kinds of range sensors.

2:50 – 3:10 p.m. Coffee break

3:10 p.m. | M. Griegoleit, St. Kühne (DE-Zittau/Görlitz)

Wireless Sensor Network based of IEEE802.15.4 with Real Time Capability

Wireless Sensor Network based of IEEE802.15.4 with real time capability The scope of this project is the development of the hardware and software basis for a wireless network, based on the standard IEEE802.15.4 and built up in a star network topology, to transmit data from remote sensors (RF-End Device) to a central processing unit (RF-Net Coordinator). The main focuses are the real time capability of the system according to the timing requirements of the project, by using a Superframe structure with a so-called "contention-free period (CFP)" and „Guaranteed Time Slots (GTSs)" as described in IEEE802.15.4, the robustness against interferences within the harsh RF environment of the widely used 2.4-GHz-band, the battery-powered operation of the sensors (and hence the energy budget) and the coexistence of several similar networks, even within the radio transmission range of a neighbouring system. The primarily targeted sensor types are pressure and torque measuring devices, but the use of other sensors or different data sources may also be possible under consideration of the system's maximum transferable data rates.

3:30 p.m. | K. Lunde, L. Kieble (DE-Ulm)

Simulating Communication within a Satellite-Based Automated Toll Collection System

In several European countries, more or less automated toll collection systems are in use, which employ a great variety of technologies. The least invasive systems use satellite-based positioning systems like GPS to detect the position and the travelled distance of a vehicle on the highway network. While vehicles are moving, communication may be caused by a variety of reasons, including toll-charging processes, software updates, or updates of geographic map data. The corresponding messages are exchanged via a mobile communications network. A similar system structure can be observed in a variety of distributed systems with a large number of mobile agents and a single computing centre where messages or requests are processed, as is often the case in vehicle telematics applications. As an example application, we consider tolling commercial vehicles on the German highway network. We have developed a simulation framework using discrete-event system simulation (DES) to explore the dependency of the frequency and the volume of the communication within a satellite-based toll collection system on essential parameter values and the choice of different update strategies. The paper focuses on communication caused by the toll-collection process. It outlines the underlying traffic model, and describes the agent model and the communication protocol. One of the challenges we address is the large number of distributed agents, which can not be reduced materially without distorting essential system properties due to the single computing centre. A discussion of some simulation results, which were attained using the DES-tool OMNeT++, concludes the paper.

End of Lecture Session

A6 Control of Mechatronic Systems

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 204

Chairman: S. Lambeck (DE-Ilmenau)

1:30 p.m.	O. Tolstykh, A. Balkovoy, V. Cacenkin, G. Slivinskaya (RU-Moskau)
Control of Direct System In many applications, independently of the motion type (linear or rotating) the direct drive systems have essential advantages in compare with the other motion systems like the motor-driven ballscrew, the motor-driven worm gear etc. The elimination of the mechanical gear provides extremely dynamic, high smoothness and precision. Moreover, thanks the relatively simple construction and minimal number of moving parts, the direct drives have extended lifetime and require no maintenance. On the other hand, in such a system, since the load is directly coupled with driving motor, any force/torque fluctuations due to non-ideal construction of the driving motor and the disturbances due to the position sensor uncertainties will negative affect on quality of motion and positioning of the load. This problem can be solved by the optimization of the driving motor construction and use the high-precision position sensor like optical encoder. However, this solution increases the cost of the direct drive system. Another way to create the high-precision direct drive system is to use the relatively low cost components and special control concept, which improves the motion performance by taking into account and compensation of force/torque deviations and uses special algorithms for position sensor error correction. This description of the direct drive system with such a control concept and results of its implementation are the main aim of this paper. The direct drive system, described in this paper, consists of the digital amplifier and the rotary table with torque motor and position measuring system based on absolute resolver. The paper contains the direct drive control concept description and several verification tests like the low speed test, the short indexing test, the high dynamic start/stop mode, the accuracy and repeatability verification according to ISO 230-2:2006 (results: accuracy – 30 arcsec, repeatability – 4 arcsec).	
1:50 p.m.	V. Piwek, B. Kuhfuss, P. Wilhelmi (DE-Bremen)
Solution for a High Dynamic Drive System Presented is a solution for a high dynamic drive system for linear motion in sections to avoid the goal conflict between high movement speed and high drive torque, which is required using conventional linear axis. In this article it is described how it can be succeeded by separating the main function "driving" in to the sub-functions "driving", "accumulate energy" and "enable energy". Within the displayed solution the drive side of the system, consisting of a servodrive and a ball screw, is extended by a mechanical energy storage which allows a significant increase of dynamic on the output side by the application of an additional brake system (fig. 1). Fig 1: Schematic diagram Besides the basic mechanical design of this system particularly the requirements on the control engineering are in focus and the effect is shown by developing a numerical process model (MatLab-Simulink). These interrelationships are illustrated with the help of a functional model (fig. 2) and verified by measuring the position with a laser interferometer. Fig 2: CAD modell of the functional model Concluding applications for the described system are shown and in the field of	

spooling machines of strip stock one is exemplified. The article closes with an outlook on further steps to adjust this solution for the industrial environment.

2:10 p.m. | R. Neugebauer, S. Hofmann, A. Hellmich, H. Schlegel (DE-Chemnitz)

Time-Based Parameter Identification And Controller Design For Motion Control Systems

Today, a cascaded system of position loop, velocity loop and current loop is standard in industrial motion controllers. Each controller has to be designed according to its subordinated system behavior. Usually, the controller commissioning is realized in the frequency domain. The resulting open-loop frequency response needs to satisfy the defined requirements (e.g. phase margin). In contrast to that, in controller engineering several tuning rules are applicable, for example the amplitude optimum or the symmetrical optimum. Therefore, an accurate parametric model is required. The paper presents a method for the identification of various plant parameters in the time domain. The approach is based on the auto relay feedback experiment by Åström/ Hägglund and a modified technique of gradual pole compensation. It is exemplified on the open velocity loop. Here, the moment of inertia and the time constant of the closed current loop are the significant parameters. In addition to a theoretical description, the paper presents the implementation as an automatic application in the motion control system SIMOTION. Finally, the velocity controller is adjusted with various tuning rules, based on the identified plant parameters. Furthermore, the identification results as well as the achievable controller performance on a test rig will be presented.

2:30 p.m. | A. Bulgakov, A. Fedorova (RU-Novotscherkassk)

Intelligent Controller for Light Weight Robot

Power Engineering Modelling and control of flexible multi-robot has recently received a wide attention from specialists in structural dynamics, mechanical engineering, and automatic control. If the various links of a manipulator are to be considered rigid, they must be structurally stiff, and this leads to bulky and massive designs. A simple adaptive scheme control structure is used to dampen the end-point vibration. It is consisted from PID controller to stabilize the system and the neural network with feedback error on-line learning scheme to control the elastic deflection by computing the joint torque that position the end effector of flexible robot along prescribed trajectory. The error in tip total displacement is used in calculating and forming the PID controller. Simulated case-studies for flexible arm had shown the effectiveness of the suggested control design scheme. Using the tip total displacement, and the feedback error on-line learning scheme of the neural network resulted in a significant reduction in the end-point vibration of the flexible link robot manipulator. Combining the PID controller with the neural network was found to improve the trajectory tracking and controlling the end-point vibration of the flexible manipulator during the tracking process and after reaching the desired position.

2:50 – 3:10 p.m. Coffee break

3:10 p.m. | A. Winkler, L. Böhme, J. Suchý (DE-Chemnitz)

Collaboration of Robots under Force/Torque Control

Force/ torque control of robot manipulators has been quite intensively investigated during the last decades and it becomes more and more important concerning manufacturing tasks. However, in the case of cooperation between industrial robots, they are predominantly position controlled. This article deals with force/ torque control based robot-robot collaboration. For demonstration a challenging task will be selected - the assembly of a screw fitting by two force/ torque controlled robot arms. This experiment will be performed using hybrid position/ force control. For the implementation two industrial robots with its original controllers have been used. This fact reduces the possibilities of force/ torque control with respect to controller structures and parameters.

End of Lecture Session

B3 - FLIM - Instrumentation & Algorithms

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: D. Schweitzer (DE-Jena)

1:30 p.m.	Welcome Speech (Audimax) Jens Haueisen (DE-Ilmenau)
1:35 p.m.	P. French (GB-London)
	Key Note Lecture: Multidimensional fluorescence imaging and metrology for high content analysis and label-free diagnosis This talk will review our development and application of multidimensional fluorescence imaging (MDFI) technology, with an emphasis on fluorescence lifetime imaging (FLIM) applied to microscopy, endoscopy and tomography. Applied to autofluorescence, MDFI can be used to provide label-free molecular contrast in biological tissue and is being investigated for ex vivo and in vivo imaging with a view to developing diagnostic tools. To this end we have developed a FLIM microconfocal endoscope and a multispectral multiphoton FLIM microscope based on the Dermalinspect platform. Applied to fluorescent labels, fluorescence lifetime imaging (FLIM) and Forster resonant energy transfer (FRET) can provide readouts of variations in the local molecular environment of labelled proteins (e.g. calcium transients) and of protein-protein interactions. To study cell signalling networks and mechanisms of disease, we have developed a range of microscopes ranging from stimulated emission depletion (STED) FLIM microscopy to study spatial phenomena with < 40 nm resolution through to multibeam multiphoton FLIM microscopy to map changes in metabolic pathways using cellular autofluorescence. For faster and more systematic investigations, we have developed an automated high-speed optically-sectioned FLIM multiwell plate reader to read out, e.g. membrane properties and protein interactions via FRET in fixed and live cells. We are also developing multiplexing strategies to simultaneously readout different protein-protein interactions. While this can increase the value of cell-based assays, for drug discovery, as well as for fundamental research, it is imperative to translate such assays to live disease models – both to further elucidate disease mechanisms and to enhance the identification of promising drug candidates while decreasing the time to failure of unsuccessful compounds. Noting that FLIM provides a robust readout, such as is required for translation to in vivo experiments, we are developing tomographic FLIM instruments based on optical projection tomography for transparent/optically cleared samples and diffuse fluorescence molecular tomography for mouse imaging.
2:25 p.m.	W.Becker (DE-Berlin)
	Probing Molecular Interactions by Fluorescence Lifetime Imaging Fluorescence imaging techniques have found broad application in live sciences because they are non-destructive, extremely sensitive, and deliver information about biochemical interactions on the molecular scale. Of all fluorescence parameters, it is the fluorescence decay function that yields the most direct insight into molecular processes within live cells

and tissues. A fluorescence lifetime imaging (FLIM) technique for biological imaging has to combine high photon efficiency, high lifetime accuracy, resolution of multi-exponential decay profiles, simultaneous recording in several wavelength intervals and optical sectioning capability. We will show that the combination of multi-dimensional time-correlated single photon counting (TCSPC) with confocal or two-photon laser scanning meets these requirements almost ideally. Multi-dimensional TCSPC is based on the excitation of the sample by a high-repetition rate laser and the detection of single photons of the fluorescence signal. Each photon is characterised by its time in the laser period, its wavelength, and the coordinates in the scanning area. The recording process builds up a photon distribution over these parameters. We will demonstrate the application of the technique to ion concentration measurements, FRET experiments, and autofluorescence imaging.

2:50 – 3:10 p.m. Coffee break

3:10 p.m. | S. Orthaus (DE-Berlin)

Recent Developments in Hardware and Data Analysis Schemes for FLIM

Time-resolved fluorescence microscopy has become very popular in the recent years and has enabled new measurement procedures such as Fluorescence Lifetime Imaging (FLIM). Today complete systems are directly available either as stand-alone units [1] or as upgrades to confocal laser scanning microscopes (CLSM) [2]. Such systems are typically based on Time-Correlated Single Photon Counting (TCSPC) electronics along with picosecond pulsed diode lasers as excitation sources. Typical FLIM applications nowadays include ophthalmology, environmental sensing or even single-molecule experiments. In this presentation we will summarize the recent developments in this field, which include e.g. a new truly parallel multi-channel TCSPC unit[3], that allows to perform FLIM measurements at a photon rate much higher than the classical pile-up limitations thereby minimizing data acquisition time [4]. We will also present a new solution in the field of compact picosecond pulsed diode lasers such as an excitation source in the green spectral range (532 nm) [5]. In addition to improvements in the area of hardware for FLIM, we will also summarize our latest results on data analysis concepts. While multi-exponential decay analysis has become a standard tool, we are working on new analysis schemes such as cumulant analysis and multidimensional visualisations to decrease the data analysis time and to identify and separate characteristic subpopulations. We will also present results that show how pulse pile-up distortions and dead time effects can be corrected in the data analysis using dedicated correction algorithms [6].

3:35 p.m. | M. Klemm (DE-Ilmenau)

A Layer Based Approach for Multi-Exponential Fitting of Autofluorescence Data in the Human Eye

Purpose: To enhance multi-exponential fitting of fluorescence lifetime imaging (FLIM) measurements in ophthalmology by refined modeling of the measured data. Methods: To

measure the fluorescence lifetime at the human fundus a modified Heidelberg Retina Angiograph was used. The endogenous fluorophores were excited by a diode laser with pico-second pulses at 446 nm and a repetition rate of 80 MHz. The auto-fluorescence was detected in two spectral channels: 490-560 nm and 560-700 nm using the time-correlated single photon counting method. A time resolution of approximately 12.2 ps was achieved by dividing the time between laser pulses (12.5 ns) into 1024 time channels. The acquired images cover 30° of the fundus with a lateral resolution of 40 x 40 μm². The same technical setup was used for cuvette measurements using a lens with 150 mm focal length. The here discussed method was first described by Schweitzer [Patent DE 10 2008 045 886]:

$$\frac{I(t)}{I_0} = \text{IRF} \cdot \sum_i a_i \cdot e^{-\frac{t-t_c}{\tau_i}} + b$$

(I - intensity, IRF - instrumental response function, € - amplitude, t - time, t_c - time-shift, € - lifetime, b - offset). It extends the classical multi-exponential model by a time-shift which allows each exponential to be moved on the time axis independent from the other exponentials. This allows for modeling of distances between fluorophores along the excitation laser beam which translate into a time lag between the fluorescence emissions of the fluorophores. Datasets from human subjects were approximated with the classic three-exponential model and with the layer based approach. Further on the algorithms were compared using simulated data which was generated by a Monte-Carlo-approach. Synthetic data was created based on given parameters ("parametric") as well as based measured data ("nonparametric"). Two regions have been analyzed: the fovea centralis and the optic disc which also affected the determination of the simulation parameters. Identical preprocessing (especially binning) is applied for both algorithms. The optimization was done with the help of a differential evolution followed by a simplex algorithm. Results: Measurements of fluorescent dyes in three cuvettes with a distance of 40 mm and 80 mm relative to the first cuvette show the principle of layered approach is valid as the calculated distances from the FLIM data are 43 mm and 80 mm. Lifetimes of the layered approach (167 ps, 1362 ps, 3347 ps) match lifetimes of single measurements (177 ps, 1272 ps, 3052 ps) while lifetimes of classic three-exponential model are significantly different (117 ps, 622 ps, 2052 ps). The "parametric" simulation with three exponentials (40 ps, 500 ps, 3500 ps) whereby the latter two are shifted by 100 ps and 200 ps respectively also show remarkable differences. The layered approach approximates 42 ps, 528 ps and 3582 ps whereas the common three-exponential model determines 39 ps, 536 ps and 4238 ps. Lifetime variances are smaller in all cases for the layered approach. Conclusions: The presented approximation algorithm is able to determine the lifetimes more accurately than the classic multi-exponential approach in layered structures such as the human eye.

4:00 p.m.	K. König (DE-Saarbrücken)
<p>Clinical fluorescence lifetime imaging in dermatology Multiphoton Tomography was performed on patients with dermatological disorders using femtosecond near infrared laser tomographs. The spatial resolution was less than one micrometer. Using time-correlated single photon counting, fluorescence lifetime imaging was performed. The temporal resolution was 270 ps. FLIM data from volunteers and patients will be presented.</p>	
<p>End of Lecture Session</p>	
4:30 p.m.	Guided tour through the Institute of Biomedical Engineering including Ophthalmology Laboratory
7:00 p.m.	Dinner in restaurant of hotel "Lindenhof" for all referents

C2 Design, Evaluation and Refinement of Intelligent Systems

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 129

Chairmen: M. Atzmüller (DE-Kassel), R. Knauf (DE-Ilmenau)

1:30 p.m.	P. Kademova-Katzarova, R. Andreev, V. Terzieva (BG-Sofia)
<p>An Adaptable E-Learning System for Pupils with Specific Learning Difficulties</p> <p>E-learning systems available nowadays are designed mainly for the high education school. However many children don't succeed to get at the universities at all, since their specific educational necessities hamper them in achieving higher grades because their specific cognitive abilities are not discovered and improved. They are known as people with learning difficulties such as dyslexia, discalculia, ADHS and ADS. They are often very creative persons but cannot cope with the so named „cultural techniques" - reading, writing, math skills etc. This paper presents an approach to development of an e-learning environment for children with learning difficulties. The education of these pupils is very tiresome and complicated due to the great variety of their specific cognitive abilities and psychological factors. It requires the existence of personalized learning facilities that help the learners in achievement of their learning goals. For that reason we design an adaptable system for development of learning facilities based on suitable pedagogical methods and learning units with appropriate volume. The system realizes a technique for adaptation of learning facilities not only to the learning profile of each pupil, but to the specific learning context and situation. The substantial elements of this technique are embedded in the activities of the facilities author. The paper describes an approach to determination of these activities that are supported by the adaptable system. The presented adaptation technique bases on reuse strategy that guarantees discovering of reusable learning units, which can be modified in correspondence with the new learner's profile, learning context or situation.</p>	
1:50 p.m.	K. Kaczor, S. Bobek, G. J. Nalepa (PL-Kraków)
<p>Rule Modularization and Inference Solutions – a Synthetic Overview</p> <p>Rule-based expert systems proved to be a successful AI technology in a number of areas. Building such systems requires creating a rulebase, as well as providing an effective inference mechanism that fires rules appropriate in a given context. The paper briefly discusses main rule inference algorithms Rete, TREAT and Gator. Since large rulebases often require identifying certain rule clusters, modern inference algorithms support inference rule groups. In the paper the case of the new version of Drools, introducing the RuleFlow module is presented. These solutions are contrasted with a custom rule representation method called XTT2. It introduces explicit structure in the rulebase based on decision tables linked in an inference network. In this case, the classic Rete-based solutions cannot be used. This is why custom inference algorithms are discussed. In the paper possible integration of the XTT2 approach with that of RuleFlow is discussed.</p>	

2:10 p.m.	B. Kämpgen (DE-Karlsruhe), F. Lemmerich (DE-Würzburg), M. Atzmüller (DE-Kassel)
<p>Decision-Maker-Aware Design of Descriptive Data Mining This paper presents two real-world case studies focussing on descriptive data mining for decision-makers. For that, we first propose a process-oriented design of descriptive data mining that helps in describing and performing such projects. Finally, we discuss important lessons learned during the implementation of the respective projects.</p>	
2:30 p.m.	M. Atzmüller (DE-Kassel), St. Beer (DE-Würzburg)
<p>Validation of Mixed-Structured Data Using Pattern Mining and Information Extraction For large-scale data mining utilizing data from ubiquitous and mixed-structured data sources, the appropriate extraction and integration into a comprehensive data-warehouse is of prime importance. Then, appropriate methods for validation and potential refinement are essential. This paper presents an approach applying data mining and information extraction methods for data validation: We apply subgroup discovery and (rule-based) information extraction for data integration and validation. The methods are integrated into an incremental process for continuous validation options. The results of a medical application demonstrate that subgroup discovery and the applied information extraction methods are well suited for mining, extracting and validating clinically relevant knowledge.</p>	
2:50 – 3:10 p.m. Coffee break	
3:10 p.m.	R. Knauf (D-Ilmenau) Y. Sakurai, K. Takada, S. Tsuruta (J-Tokyo)
<p>Validation of a Data Mining Method for Optimal University Curricula The paper deals with modeling, processing, evaluating and refining processes with humans involved like (not only, but also e-) learning. A formerly developed concept called storyboarding has been applied at Tokyo Denki University to model the various ways to study at this university. Along with this storyboard, we developed a data mining technology to estimate success chances of curricula. Here, we introduce a validation method for this technology and its results. Further, we discuss chances to improve these results by implementing a formerly introduced learner profiling concept that represents the students' individual properties, talents and preferences for personalized data mining.</p>	
3:30 p.m.	F. Batarseh, A. Gonzalez (US-Orlando), R. Knauf (DE-Ilmenau)
<p>Validation of Knowledge-Based Systems through CommonKADS This paper defines a method that can be used for validating intelligent systems throughout their entire lifecycle. Specifically, this method is incorporated within the CommonKADS</p>	

process. The lack of suitable, rigorous and general validation methods has become a serious obstacle to user acceptance of knowledge-based systems for critical applications. In spite of recent significant advances in validation of knowledge-based systems, it still remains an open problem. Many knowledge-based systems are validated using informal and arbitrary approaches. The ideas presented in this paper are based on the concept that validation should be performed in a structured and guided manner, integrated within a knowledge-based systems' lifecycle development method. The most accepted knowledge-based systems development method is CommonKADS (Knowledge Acquisition and Design Support), a structured set of models to guide development and design of intelligent systems. CommonKADS doesn't currently include guidelines for validation, verification or testing in any of its models. We establish a direct relation between validation and CommonKADS and define an incremental validation method for knowledge-based systems based on extracting test cases from CommonKADS. Furthermore, we introduce our method for reducing the number of test cases and thus reducing validation's effort and cost.

End of lecture session

C2 Design, Evaluation and Refinement of Intelligent Systems

Time: Monday, 13.09.2010, 3:50 p.m.

Location: Humboldt-Building, Lecture Room 129/Foyer

Poster Session:

Chairmen: M. Atzmüller (DE-Kassel), R. Knauf (DE-Ilmenau)

M. Schneider, F. Calcagno, M. Stieglitz, U. Lehmann, J. Krone (DE-Iserlohn)

Higher Generalization Performance of Artificial Neural Networks without Reducing Large Databases

At the training of artificial neural networks (ANN) by using a large data base of complex processes is often the problem, that the trained ANN has a good generalization only for partial data. Furthermore, the time required for the training of a large number of data sets and according to training algorithm increases huge. A lesser amount of data per neuron reduces the training time and increases the model precision. This can be achieved by reducing the data base, where data reduction is as well always associated with data loss. This can be prevented if the existing data base is divided into several submodels, which together form a complete model. The large amount of data sets is divided into several subsets without losses of data sets. An individual sorting is needed per input neuron because only with the help of this individual sortings it is possible to simulate an unknown data set. Having multiple output neurons, it is helpful to train an ANN for each output neuron to reduce the model error. Thus, the entire model consists of $T * S * A$ several ANN. T = number of data subsets S = number of input neurons A = number of output neurons During simulation for each sorting the appropriate partition is determined for the new data set. Thus, a calculation is accomplished with the ANN of the respective partition. Per output neuron as many results can be calculated as input neurons are present. These are combined excluding extrem values by the mean value is calculated over the remaining parts of the partial solutions. By this way of the distribution of the process knowledge the generalization performance of the complete model could be increased. In addition the complete training duration could be shortened.

**ABC1 Ambient Assistant Living - Modular and
Mobile Systems for AAL**
Time: Tuesday, 14.09.2010
Location: Humboldt-Building, Lecture Room 202
Chairman: St. Lutherdt (DE-Ilmenau)

9:00 a.m.	P. Nauth (DE-Frankfurt/Main)
<p>Intelligent Behaviour of Humanoid Assistive Robots</p> <p>Robots operating under not standardized conditions such as assistive robots must understand the goals a user wants to be achieved, recognize the environment in context with the goals, develop strategies to execute them and act autonomously. By means of intelligent sensors for speech recognition, proximity measurement, color measurement and image processing an intelligent humanoid robot has been developed. It understands a goal by recognizing the name of an object a user has told the robot to take and searches for it by means of a smart camera and other sensors. After it has found and identified the object, it grabs it and brings it to the user. The speech recognition sensor and the smart camera can learn new words as well as shapes and colors of new objects respectively in order to cope with new situations. The method used is supervised learning. Camera and proximity sensors are mounted on the turnable head of the robots in order to acquire 3-D information about the object shapes. By fusing auditive, visual and distance function data the robot knows its goal as well as all objects and obstacles in its environment. It develops a plan to overcome the obstacles and to approach the object it is advised to fetch. We apply the algorithms to small humanoid robots. The advantages of small sized robots over other systems are reasonable deployment costs and scalability. However, small robots alone cannot carry heavy or big objects or reach these lying in higher levels. We solve this problem by the swarm robot approach where several robots co-operate as a team solving a difficult task together.</p>	
9:20 a.m.	Th. Meier, A. Günther, Ch. Richter (DE-Leipzig)
<p>A modular system for building automation</p> <p>This presentation will introduce a modular system for building and home automation that can be applied to a wide range of scenarios, for example, energy management and ambient assisted living. Because of the modular structure, our system can be used in a lot of different scenarios. For example, it is possible to implement a central as well as a decentral management of the system. Beside the modular structure, one of the project main goals was to develop a generic system to integrate sensors and actuators already in existence. Therefore, we have implemented a gateway to connect a wide range of proprietary devices from different manufacturers with our system independent of their specific communication interface (for example ZigBee, WLAN, USB etc.). The task of the gateway is to translate these different technologies to a uniform interface (UPnP). This interface is used by the controller to interact with the sensors and actuators. The controller is responsible for the execution of the system logic, for example, a heating control system or an alarm system. The controller implements a web service interface to facilitate the configuration of the controller by a various number of different clients, such as Home Control Interface, Management Server or a mobile device.</p>	

9:40 a.m.	V. Shulgov (BY-Minsk)
<p>Adaptive Electrostatic Seizing Device</p> <p>This paper presents the design and control circuit of the Electrostatic Seizing Device of robotics. The device makes it possible to fix and handle flats conductive or semi-conductive parts on the basis of their approximate weight.</p> <p>The control circuit consists of a computing device (either microprocessor or microcomputer), interfacing device and controllable high-voltage source. The computing device specifies the high voltage to be applied to the electrode of the seizing device via the interfacing device according to the approximate weight of the part. The value of this voltage is limited by the thickness and electrical strength of the dielectric. In our case, the dielectric is anodic aluminium oxide with the thickness of 30-100 μm, the electric strength of which is 40 kV/mm. The working head of the device is provided with a touch sensor that makes it possible to determine the moment of touching or taking-off of the work-piece. The touch sensor confirms also the fixation of the part or gives a command for increasing the working voltage. This system makes the "manual training" unnecessary, increases the precision of the positioning the part and makes it possible to fix the parts with a buckling defect.</p>	
10:00 a.m.	S. Hellsper, H.-M. Groß (DE-Ilmenau)
<p>Estimating Light Regions in Indoor Environments for a Mobile Robot Cameraman</p> <p>This paper presents an approach for determining an illumination model used by a mobile robot in an indoor living environment. Detecting light sources and estimating the illumination situation are important basic principles in order to find an optimal pose for observing a person, because lighting is one of the fundamental aspects which affects image quality. The robot has to cope with high dynamic range of scenes and with changing lighting conditions. In a first step, irradiances of the environment are estimated. Sections with high irradiance values are defined as light regions. Unlike other approaches which describe illumination, in this paper not only the lighting situation at one particular position shall be estimated but also for several poses in a room in relation to the observed person.</p>	
10:20 – 10:40 a.m. Coffee break	

10:40 a.m.	D. Ammon, V. Detschew (DE-Ilmenau)
<p>Knowledge-oriented Analysis and Support of Medical Documentation</p> <p>The documentation of medical treatment is a knowledge-intensive task for structuring and organizing healthcare activities. Most of the approaches in computer-based patient records are, however, focusing on details of data management or user interaction. In this contribution, a method for a knowledge-based analysis of the healthcare process "medical documentation" is outlined, from which requirements to a knowledge- and process-oriented electronic medical documentation are derived. A prototypical architecture for an electronic documentation function which depends on an encyclopedic, disease-based representation of medical knowledge is suggested. In conclusion, potentials and open issues for the proposal of analysis and design of knowledge-oriented healthcare information systems are discussed.</p>	
11:00 a.m.	S. Röhr, D. Ammon, V. Detschew (DE-Ilmenau)
<p>Medical Workflow Assistance with Clinical Pathways: Bridging the Gap</p> <p>Presently, public health is more and more focusing on standardized treatment of certain diseases. The introduction of clinical pathways in healthcare institutions is a gradual approach to optimize quality, time, costs and service in terms of evidence-based treatment standards. However, clinical pathways as process models are currently often used for documentation aspects of present situations. In this contribution, we presume a lack of procedural support in the current use of clinical information systems. Therefore, a methodic and technical approach of transferring appropriate clinical process models into daily routine via workflow-based health information systems is suggested. We give a description of a structured semiformal process modeling in UML, and propose the application of a model-driven architecture for the transformation of general process models into standard xml-based languages of workflow-supporting health information systems. The contribution sets a work plan and closes with the discussion of open issues in the introduced method.</p>	
12:00 noon – 1:30 p.m. Lunch	
End of Lecture Session	

Poster Session:
Chairman: St. Lutherdt, F. Roß (DE-Ilmenau)
S. Linß, I. Gavrilova, V. Unger, T. Kikova, H. Witte, L. Zentner (DE-Ilmenau) Development of an Adaptive Support Device for the Prevention of Bedsores Constant long-time compression of the skin may cause bedsores especially in case of immobile hospital patients or bedridden people. Even with optimal quality of care painful skin lesions can occur that range from simple reddened skin to open pressure ulcers. The high prevalence figures and the associated economic, ecological and social effects indicate the need of improved prevention systems. Therefore, an approach on the development of an adaptive support device to prevent bedsores is presented in this paper. A supporting evaluation of the pressure ulcer risk can be provided by the determination of the load situation acting on the skin as well as other factors of the microclimate. For the bionic development process the human skin with her special three-dimensional geometry of the boarding surfaces of the layers as well as the distribution of biological sensors and actuators is particularly interesting as the source of inspiration for the technical implementation. The analysis of the state of the art and the consideration of abstracted biological principles result in a demonstrator from silicone, which can be used for the investigation of basic functions of support systems. Furthermore the realization of new properties, like an optimal distribution of pressure and a minimization of shear forces, can be realized by the layered compliant structure. With the integrated sensor and actuator technologies an efficient adjustment of the stiffness and therewith of the sensitivity is possible too. The system to be developed enables the detection of critical pressure values as well as the dedicated stimulation of susceptible skin areas and it can be used in a system for pressure ulcer prevention.
I. Vrublevsky, A. Tuchkovsky, K. Chernyakova (BY-Minsk) Light-emitting diode modules of small size for the phototherapy devices LIGHT-EMITTING DIODE MODULES OF SMALL SIZE FOR THE PHOTOTHERAPY DEVICES I. Vrublevsky, A. Tuchkovsky, K. Chernyakova Belarusian State University of Informatics and Radioelectronics, Minsk, P. Brovka Str., 6, Belarus, 220013, e-mail: vrublevsky@bsuir.edu.by Light-emitting diode (LED) module developed for the phototherapy devices is intended for the preventive measures and treatment of the rhinitis by the blue light waves of the low-energy and narrow-beam. Power blue light wave emitting by LED has the phototherapeutic effect and in the first place is destined to the irradiation of Schneiderian membrane of the patient. It is well known that waves of the blue range possess the antimicrobial action. To fabricate LED module of small size heat-conducting aluminum substrate with nanoporous anodic alumina with the extra heat sink (the heat tube made of copper) has been used in the present study. The structure of LED module developed allowed increasing the efficiency

of the heat removal and decreasing the temperature of operation of LED's die considerably. To mount a super-bright LED the aluminum substrate with nanoporous anodic alumina of 20 mm diameter has been utilized. LED's performances: 1 V power, 440 nm wavelength, focusing lens of 60°. The layer of anodic alumina of 75 μm thickness has been used as an insulator. Anodic alumina has been obtained in the aqueous solution of oxalic acid by the electrochemical anodization of aluminum. Anodic oxide was absent on the one side of the circuit board in order to increase the heat-conductivity. Vanadium-copper films have been used to form conductivity plane. Vanadium sublayer has been formed by the vacuum evaporation. The deposition of copper layer has been carried out by the galvanic method. Immersion tin has been applied to solder the contact pads. The photometric characteristics of the LED module have been determined. The LED module is shown to allow obtaining the illumination of 30,000 lux at the distance of 3 cm.

**A2.2 - Modelling and Optimisation of Water Resources
Management Systems**
Time: Tuesday, 14.09.2010
Location: Humboldt-Building, Lecture Room 010
Chairman: Th. Rauschenbach (DE-Ilmenau)

9:00 a.m.	A. Gnauck (DE-Cottbus)
<p>A Simulation Framework for Freshwater Eutrophication Management</p> <p>Eutrophication of freshwater ecosystems is characterised by an intensive increase of dissolved nutrients in water bodies, by excessive growth of green plants, mainly algae, by decreasing transparency, by anoxic conditions of deeper water layers, by loss of biodiversity, by restricted water uses as well as by taste and odour problems. Man-made impacts have been caused shifts in the states of freshwater. To obtain control options for the eutrophication management of a river basin a modelling and simulation framework was developed. It consists on a MATLAB based stationary 1D-eutrophication model for shallow water bodies combined with an optimisation tool. Modern time series analysis methods were used for process identification. Model state variables are given by algal biomass, zooplankton, orthophosphate phosphorus, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen as well as by dissolved oxygen and biochemical oxygen demand. The phosphorus remobilisation from sediment was included in the phosphorus balance equation. Dependencies of ecosystem state variables of external driving forces are modelled by analytical and regression type functions. For parameter optimisation the software tool ISSOP was used. For simulation and eutrophication management the river basin of the Lower Havel was divided into several river segments of different length's and hydraulic characteristics. Basic Simulation runs for algal biomass (y_1), orthophosphate phosphorus (y_2) and nitrate nitrogen (y_3) are carried out. To compute optimal management strategies options the following goal functions are used: Algal biomass $f_1(t) = \sum_x \sum_t y_1(x, t) \rightarrow \min.$, orthophosphate phosphorus $f_2(t) = \sum_x \sum_t y_2(x, t) \rightarrow \max.$, nitrate nitrogen $f_3(t) = \sum_x \sum_t y_3(x, t) \rightarrow \max.$ Two management strategies are considered: (i) Natural strategy according to limiting nutrient concept (LNC). (ii) Impact strategy according to LAWA concept. Management options according to LNC lead to a diminished phytoplankton maximum in late summer by optimised nitrate concentrations. No effect of optimised orthophosphate phosphorus concentration can be stated. On the other hand, management options according to LAWA regulations lead to nearly the same behaviour of algal biomass in spring but to smaller differences of phytoplankton maxima and to low nutrient concentrations in late summer. As a result the LAWA concept leads to significant lower nutrient concentrations but to a slight increase of phytoplankton biomass. In opposite of that an eutrophication management according to the LNC results in lower phytoplankton concentrations but higher admissible nutrient inputs.</p>	

9:20 a.m.	D. Karimanzira, Th. Rauschenbach, H. Linke, Th. Bernard, O. Krol, M. Jacobi (DE-Ilmenau)
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A Simulation-Optimization-Based Decision Support System for Water Allocation

Water is critical, but often overlooked element in sustainable development. The paradigm encapsulated in the "Beijing water allocation decision support system" (BjWDSS) explicitly challenges conventional, fractional water development and management systems and places emphasis on integrated approach with more coordinated decision making across sectors and scales. Recognizing that exclusively top-down, supply-led, technically-based and sectoral approaches to water management are imposing unsustainably high economic, social and ecological costs on human and on the natural environment. BjWDSS utilize optimization techniques to facilitate optimal decision making in the planning and management of especially large scale water resources systems. A water system involves several stakeholders with different, often conflicting objectives, and thus the proper framework for the statement of the decisional problem under consideration should be that of multi-objective decision analysis. Therefore, BjWDSS couples a simulation model based on the RiverMod-Library with numerical search methods IPOPT/HQP for optimizing relevant decision variables. The concept is tested and now in application on the large scale Beijing water supply system, where all challenges of water resources management come together. Beijing is in a temperate zone with a semi-humid monsoon climate. Rainfall varies geographically, seasonally and yearly. Eighty-five percent of rainfall falls between July and September. At times, 40-70% of rainfall falls within 3 days. Beijing's total population has topped 17.4 million. With population growth and expansion of the economy, water demand has increased dramatically. Aside from problems such as excessive withdrawal and water quality deterioration of surface waters, the lack of regional coordination leads to issues such as uncoordinated withdrawals and upstream water contamination. The results of the DSS show that the concept significantly improves the water system's performance in terms of sustainability, efficiency and survivability.

9:40 a.m.	Th. Bernard, O. Krol (DE-Karlsruhe)
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Modelling of Algae Growth by combining Fuzzy Logic and Finite Element Method

One of the main challenges for modelling of spatial distributed phenomena is the estimation of the model parameters. For many environmental processes (e.g. biochemical or biophysical processes) the physical phenomena like flow and mass transport can be described by partial differential equations (PDEs) of fluid dynamics, but for parameters like growth rates often no analytic models are available or the existing models require a large number of parameters which are hard to determine. However, in many cases experts have knowledge about the system behaviour that can be formulated by a set of IF...THEN rules. As this kind of knowledge can easily be handled by so-called Fuzzy models we propose the coupling of Finite Element models with such Fuzzy models. By this means one or more parameters of the classical PDEs are estimated by Fuzzy Models. Besides the natural inclusion of expert knowledge a second benefit of this approach consists in the fact that Fuzzy Models can describe even very nonlinear phenomena. The calculation of the Fuzzy model consists in the steps (1) Fuzzyfication, (2) inference and (3) defuzzyfication. Within

step (1) the considered input/output variables are transformed to linguistic variables. In the inference unit (step (2)) the actual processing of the linguistic variables is performed whereby IF...THEN rules have to be formulated by experts that describe the interdependence of the input parameters to the output parameter(s). The defuzzification (step (3)) generates crisp physical output values of the Fuzzy model. The concept of coupled Fuzzy and FEM models is demonstrated by the modelling and simulation of algae growth in flat water bodies and related eutrophication effects. The proposed approach is very suited for this problem as the hydrodynamics is well understood whereas the biochemical processes are still a topic of research and the developed models are very complex and require a big number of parameters. Since in general the required parameters (e.g. growth rates) are not measurable for the entire model domain the idea raised to estimate them by taking the main variables (e.g. temperature, fluid velocity, nutrients concentration) into account and estimate the algae growth rate by Fuzzy model.

10:00 a.m. | Th. Westerhoff, B. Scharaw (DE-Ilmenau)

Sensor based Leak Detection in Urban Water Supply Systems on the example of the drinking water distribution network of the city of Darkhan, Mongolia

Leakages and the water loss caused by them are one of the most important problems in urban water distribution systems. Because water supply networks are located below the surface it is very difficult to detect leakages. Only large leaks generate through the ground. Currently leak detection happens manually by pacing off the pipes and listening to the typical noise produced by leakages. Therefore one has to know the approximate position of the leak. Another method to detect the leak position on one single pipe is the use of acoustic correlators. Fraunhofer AST takes part at an IWRM (Integrated Water Resource Management) project in Mongolia. In the city of Darkhan, the largest city in the project area, the water loss is about 45% of the fed in water. The positions of the leaks are unknown. The use of correlators is difficult because the pipes are installed very deep into the ground. The intention of the project is to install a pre-defined amount of some combined pressure-/flow-/noise-sensors at selected nodes in the supply network. There are two goals in the project. First is to estimate the position of the leak by pressure measurement. Network outflow (consumer demands, leakages) produces a typical pattern of hydraulic head over the network caused by the head loss in the pipes. Because the consumer demand will change with a typical profile during the day and the amount of leakages depends on the net pressure it is possible to estimate the position of leaks by using evolutionary optimization algorithms in combination with a hydraulic simulation using the software tool HydroDyn. The disadvantages of this approach are the requirement of exact demand profiles as well as very accurate pressure and flow measurements. To increase the accuracy another approach with additional acoustic sensors which measure the noise in the water network will be developed. When a leakage occurs then a typical noise propagates through the network with the speed of sound. That speed varies with the water temperature, the flow directions and the structure of the network. With the knowledge of these parameters a very fast detection of the leak position will be possible short after the leakage occurs.

10:20 – 10:40 a.m. Coffee break	
10:40 a.m.	D. Schwanenberg, G. Verhoeven, L. Raso (NL-Delft)
<p>Nonlinear Model Predictive Control of Water Resources Systems in Operational Flood Forecasting</p> <p>We present a Nonlinear Model Predictive Control (NMPC) algorithm for real-time decision support on the management of water resources systems in operational flood forecasting. The algorithm consists of an iterative, finite horizon optimization of the system over a short-term control horizon. The underlying process models are a set of nonlinear ordinary differential equations. Depending on the physical properties of the specific system, these equations are solved numerically either by an explicit or implicit time stepping scheme. Objectives of the control, i.e. the desired damping of flood peaks, and constraints such as the water level dependent capacity of a structure are mathematically formulated by a set of objective functions and inequality constraints. The resulting optimization problem is solved by Sequential Quadratic Programming (SQP). For enabling the real-time application of the algorithm, we present the derivation of adjoint systems on the discrete level of the process models for computing the gradient of the objective function related to the controlled variables at the computational costs of a single model execution. The algorithm is applied to i) the control of a reservoir system of four reservoirs and ii) to the control of six hydraulic structures and two major flood detention basins along the bifurcation points of the Rhine River in the Netherlands.</p>	
11:00 a.m.	A. Gnauck, B. Luther (DE-Cottbus)
<p>Parameter Optimisation and Sensitivity of an Eutrophication Simulator</p> <p>Modern environmental management decisions are based on simulation models of ecosystems or ecological processes. To get suitable results for management purposes the process of setting up of parameter values and initial conditions is of high importance. Options for eutrophication management will be obtained by scenario analyses with changing parameter values. For the determination of quantitative values of parameters three different approaches can be taken: A preliminary estimate is obtainable from laboratory and field observations of processes and effects by means of correlation analysis or by parameter estimation techniques. Combinations of parameters in keeping with a modelled situation may be obtained by means of estimation from parameter optimisation techniques. Estimates of parameter importance of a simulation model may be obtained by sensitivity analysis which is important for model validation. Investigations of parameter changes are carried out for an eutrophication simulator of a lowland river basin. Three classical approaches to sensitivity analysis can be distinguished: Sensitivity to major parameter changes (The values of some parameters are arbitrarily changed within the expected limits of their validity, and the response of system investigated). Experimental sensitivity analysis (The parameter values p_i are changed by a finite amount Δp, the model rerun and model outputs for nominal and changed parameter vectors abstracted. The result depends on Δp). Analytical sensitivity analysis (Sensitivity functions are calculated representing partial derivatives of state variables u_j to parameters: $S(p_i) = \partial u_j / \partial p_i$. This method of sensitivity analysis is based on linearisation around the nominal solution).</p>	

Estimating sensitivity to external parameters, those connected with driving variables or site constants, a picture is getting how a given freshwater ecosystem would behave under different conditions. For internal parameters, the goal is too determine the importance of parameters for the adaptability of the model to reality. Eutrophication is referred to algal growth and intensive increase of dissolved nutrients within the water body. These man-made impacts influence matter fluxes and biological activity of a freshwater ecosystem. Therefore, those parameters connected with algal growth are of special interest for eutrophication management. In the paper, results of a parameter optimisation and sensitivity analysis of an eutrophication simulator are discussed. The influences of internal and external driving forces on parameter changes are demonstrated. The importance of parameters is visualised by ranking with Hasse diagram technique. The output of the eutrophication simulator investigated is most sensitive for parameters characterising algal growth and dynamics. A second level of sensitivity is given by parameters describing nutrient cycles within the water body. In opposite of that, the food chain based influence of zooplankton to phytoplankton was found very stiff.

12:00 noon – 1:30 p.m. Lunch

End of Lecture Session

A3.1 Analysis and Synthesis to Energy Efficiency Optimisation

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 011

Chairman: D. Westermann (DE-Ilmenau)

9:00 a.m.	K. Meyl (DE-Furtwangen)
<p>About the Classical Electrodynamics and Practical Applications Influenced by the Discovery of Magnetic Monopoles</p> <p>"Science" reported in the issue from October 2009 about the discovery of magnetic monopoles. Magnetic monopoles could be the missing link in a new understanding and explaining James Maxwell's third law of classical electromagnetism, since the divergence of magnetic flux density would no longer be zero but a duality to charge carriers would exist appearing as magnetic monopoles. As a result Maxwell's Theory loses its universality and an extension to his theory becomes necessary thus impacting classical electrodynamics, especially the vector potential A, ($B = \text{curl } A$), which requires the validity of the 3rd Maxwell equation ($\text{div curl } A = \text{div } B = 0$). Take well-known eddy currents as an example tending to expand as demonstrated by the skin effect. Now the dual anti vortex with opposite sign appears showing the contracting effect of the potential vortices. They possess a structure-forming characteristic with which the formation of closed field vortices in the air can be explained. Since these field eddies carry energy and as a longitudinal wave are propagating, comparably with an acoustic wave, the wireless transmission of energy is physically conceivable and mathematically derivable as a possible application. With the publication in "Science" for scientists, as well as for users, the gate to a new world in physics has been opened, even if this has not been noticed by all.</p>	
9:20 a.m.	T. Behrmann, C. Zschippig, M. Lemmel, S. Bosse (DE-Bremen)
<p>Toolbox for Energy Analysis and Simulation of self-powered Sensor Nodes</p> <p>As the numbers of available high performance but low-power embedded systems rise, new application scenarios for tailored sensor systems get in reach to be implemented. In some cases battery powered or self-powered systems are needed, e.g. in the context of wireless sensor networks. The question has to be considered, if the system has enough energy and always enough power to fulfil its task. Often the answer can only be given, in case the analysis is carried out in the context of the real application. A simulation on this will only be meaningful, if it describes the environmental condition of this context as well. Therefore we propose a simulation toolbox for energy and power analysis of independent sensor nodes. This presentation shows the foundations of a new simulation toolbox, a tool for designing modular sensor systems. The focus of this tool will be on the economic and efficient use of power and energy on the level of embedded systems. The base of the toolbox is a growing number of simulation blocks modelling the power behaviour of embedded modules like energy sources, converters, storage and load. A set of tools for observing losses, energy throughput and power lags, assists the system designer to set up an economic solution. A strong emphasis lies on the modelling of modern energy harvesting principles and the embedding physical situation. One main goal of this research work is to overcome the principle of always over-sizing the power supply of electric system for the "worst case". Instead a situation-dependant adaptive energy management will set different operation</p>	

modes of embedded systems to cope with power supply and energy situation. Therefore these systems will act much more reliable than the traditional ones. To save energy, the different operation modes will lead to a tailored sensor data processing. Instead of using a full micro processor, the next development steps are configurable hardware blocks. Therefore the load models will consider different implementations on work task level. A simple but comprehensible example will show the possibilities of system analysis and should lead to a productive discussion about future enhancements from the point of view of system designers and users.

9:40 a.m. | M. Geske, K. Lipiec, P. Kamarnicki (DE-Magdeburg)

Influences of Electric Mobility on Medium- and Low-Voltage Power Grids

Due to the political goals of the German government the amount of electric vehicles will increase in Germany in the years to come. The starting points of the development of electric mobility include exemplary the reduction of CO₂-emissions and dependency on fossil fuels as well as concepts for mobile storages and mobility in urban areas. Thus, future demands on the distribution power systems depend on charging behavior and characteristics of electric vehicles taking into account an increasing dispersed generation. The influences of multiple charging processes on a medium- and low-voltage power system are going to be investigated within a modeled distribution power system. The modeling is oriented to realistic power network that consists of a medium- and low-voltage power system. The impacts of charging electric vehicles on the modeled distribution power system will be simulated by means of defined scenarios related to a specified amount of charging processes associated to the electric vehicles. The load profiles caused by instantaneous charging electric vehicles are going to be developed through reasonable charging times and quantities allocations applied to chosen nodes. The further studies are going to reveal voltage profiles and change of the load distribution respectively the impacts of electric vehicles on the modeled distribution system. The corresponding examined relationships will be the base of the final evaluation of influences.

10:00 a.m. | St. Nicolai, H. Rüttinger (DE-Ilmenau)

Smart Grid Research and Development Platform

Within the project "Smart Grid Management" the Fraunhofer "Smart Grid Research and Development Platform" was planned, installed and put into operation. Providing a technical basis for investigations on the issue Smart Grid is the objective of this platform, composed of distributed generation units, storage systems and consumers. Several photo-voltaic systems and a small scale vertical wind power generator represent the generation side. A mid-size Redox-Flow battery constitutes the core of the system. Additionally two short-term flywheel storage systems are installed. Consumption is represented by a heat pump, a electrical damper register, electric vehicles, domestic appliance and a flexible electronic AC load to emulate different load characteristics. The implemented electrical grid connecting the different assets allows investigations on real scenarios e.g. grid parallel or island grid operation. Utilizing a modern SCADA system in combination with distributed energy management systems all relevant data from the assets are aggregated and the operation of

various grid modes as well as researches on specific components is enabled. The emphasis of research activities is the coordinated operation of the "Smart Grid Research and Development Platform". Based on the modelling of the component parts of the Smart Grid and the simulation of the operational management strategies, the implementation of the strategies into the real system and the validation of the functional capabilities is shown. A new approach in the field of Smart Grid is the inclusion of grid state into overall system management. Therefore a monitoring system is installed to gather the global state of energy supply systems via PMUs. Monitoring load flow and phase shift in real-time new concepts of grid operation can be developed to improve the quality of supply as well as the integration of distributed generation. Other highly topical research issues to be analyzed are e.g. the effects of electric vehicles on distribution grids, the development of concepts for the operation of energy storage systems, forecast algorithms for renewable generation as well as the concepts for an adaptive grid protection. The project "Smart Grid Management" will be introduced and first analyzes and results will be presented.

10:20 – 10:40 a.m. Coffee break

10:40 a.m.	M. Götze, T. Zossbach, A. Schreiber, S. Nicolai, H. Rüttinger (DE-Ilmenau)
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Distributed In-House Metering via Self-Organizing Wireless Networks

Smart metering, the deployment of digital metering equipment with added functionalities, is a hot topic in building infrastructures. While smart meters enable improvements upon the transparency and efficiency of energy consumption for larger objects such as entire homes or apartments, advances in wireless and sensor technologies promise additional benefits through the implementation of sub-metering solutions, i.e., the deployment of interconnected sensor nodes measuring energy consumption per consumer. In its first half, this contribution details the experiences made in the setup and operation of a wireless sensor network for monitoring, i.a., power consumption at individual outlets in a pilot installation, discussing the network's hardware platform, software components, and lessons learned regarding practical issues of deployment. The contribution furthermore contains a user report and outlines the increase of knowledge caused by the use of these additional sensors. Hereby a segmentation of the total consumption and an allocation to the different domestic appliances is enabled. Furthermore an approach is presented how this additional data is integrated into a home energy management system to realize the Smart Home. Guidelines to this energy management system are given, e.g., by the local grid operator or the energy supplier in terms of a load schedule. Using the existing degrees of freedom, like the load shifting potential, the energy management system is switching domestic appliances on or off as well as controls the power consumption. Major goals are the active involvement of the customers into the Smart Grid management and the increase of efficiency in energy usage. At the end the presented concept and approach is summarized and an outlook on further approaches of intelligent home automation is given.

11:00 a.m.	Se. Ritter, Sa. Ritter, H. Rüttinger, S. Nicolai, P. Bretschneider (DE-Ilmenau)
<p>Optimal Planning and Operation of Power Supply in Liberalized Energy Markets</p> <p>The increasing number of distributed energy resources (DER) connected to the electrical grids at the medium and low voltage level offers a high potential of optimization in terms of distribution grid operation. Approaching an influence on the voltage profile along the distribution lines and cables as well as a minimization of grid losses are the major goals. In particular the reversal of the power flow is directly linked to the voltage profile as e.g. the feed-in of active power instead of active power consumption causes a voltage rise at the grid connection. Furthermore the supply of reactive power by DER can be used to compensate the reactive power demand of the distribution grid and as a result to minimize the grid losses. Within the framework of this article the possibilities offered by controllable inverters of DER in terms of voltage-reactive power optimization (V-Q-Optimization) and active power-reactive power optimization (P-Q-Optimization) are presented. Based on an actual example the differences in active and reactive power flows at two scenarios are discussed. Case 1 describes status quo where DER have a preset power factor in contrast to case 2 where the power factor of the DER is optimized and set dynamically. Benchmark – and hence the objective function – is the minimization of distribution losses caused by the transmission of electrical power. In addition the effect of DER on the voltage profile to counter local voltage changes is demonstrated. Also the possibility of power flow optimization in dependence on the local ratio of resistance to reactance (R-to-X ratio) of distribution lines and cables is discussed. The approaches are evaluated by simulation computations based on the measurements and grid parameters of a real distribution grid within the framework of the E-Energy project “eTelligenz”.</p>	
12:00 noon – 1:30 p.m. Lunch	

A3.2 Analysis and Synthesis to Energy Efficiency Optimisation

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 011

Chairman: P. Bretschneider (DE-Ilmenau)

1:30 p.m.	S. Klaiber, S. Nicolai, P. Bretschneider (DE-Ilmenau)
<p>Acquisition of Grid Losses Using Intelligent Forecast Methods</p> <p>A part of electric power is lost at transmission due to transport, transformation and consumption in the transmission facilities. The energy used for compensation of these physical caused grid losses is known as grid losses energy. Operators of electricity grids are obliged to obtain losses energy at a market-based procedure. Transmission system operators (TSO) themselves occur in the market for electricity to acquire such energy services in their own procurement processes as a result of the unbundling required by law and regulations of the Federal Network Agency. For an acquisition of the energy necessary to compensate the grid losses in a control area as costs minimal as possible intelligent and efficient methods for the forecast of grid losses are needed. Within the framework of this article a method used for the forecast of grid losses in a transmission grid is presented. The amount of grid losses in addition to the grid load depends on a number of exogenous factors. In the modeling process the identification of the exogenous factors is of vital importance. Boundary conditions such as the availability of data affect the way in which exogenous factors in practice may be used for the forecast of grid losses. By situational changes in load flows in a transmission grid greatly time variant dependencies of the grid losses to its exogenous factors are detectable. The actual application necessitates specific requirements in forecast strategy and the concept of the forecast method. Artificial Neural Networks (ANN), which are able to map non-linear coherences at an incomplete describable process in a model, are used as model approach for the forecast method. In this context various special network architectures were investigated. The developed grid losses forecast method as the result of the work represents an extension of ANN at an auto-adaptive method for continuous evaluation of the input data and internal parameters. The method was implemented in software engineering and embedded in the energy management system PROPHET Solutions.</p>	
1:50 p.m.	S. Ritter, P. Bretschneider (DE-Ilmenau)
<p>Stochastic Optimization of Power Supply Processes in Liberalized Energy Markets</p> <p>State-of-the-art decision support systems are indispensable for the optimization of power supply processes. There is a variety of reasons for this e.g. the essential modifications in the energy policy in recent years and attended by this a continuously raised number of determining factors as well as ever increasingly complex boundary conditions of optimization models. At the optimization of power supply processes with the objective of minimizing total cost and under supply guarantee considerations determining factors such as the feeding-in of fluctuating renewable energy, the energy demand of private and industrial loads, the prices for energy trade (e.g. charges at the spot market or charges for primary energy carriers) or weather fore-casts are usually stochastic and hence are subject to risks and uncertainties to a great extent. The consideration of these uncertainties in the optimization models should therefore be an essential requirement for the decision support</p>	

system used. Within the scope of this paper for a specially selected decision support system a possible way to make these stochastic optimization problems numerically solvable is presented, in particular by describing the stochastic of determining factors by a finite number of scenarios. This description is realized by state-of-the-art methods for construction and reduction of scenario trees which have to be constructed and reduced in such a way that information about the distributions of the stochastic determining factors are represented as precisely as possible. A summary and evaluation of the presented results constitute the finalization of this paper. In addition the finalization of this paper will give a prospect of continuative research activities in the field of stochastic programming to generate optimal decisions by randomness influences.

2:10 p.m. | H. Zhang, P. Li (DE-Ilmenau)

Chance Constrained Programming for Optimal Power Flow Taking Account of the Load Power Variation

In power system operations, the future power load is not known precisely as its value fluctuates from time to time. This stochastic nature of load makes load forecasting errors always exist. In this paper the load variation is taken into account to optimal power flow (OPF) problems and is considered as a random vector associated with normal distribution. Monte-Carlo simulation (MCS) is made to investigate effects of the random inputs to the system operation. Then, a solution strategy with chance constrained programming (CCP) is implemented to deal with the uncertainty with which the inequality constraints of the formulated optimization problem can be transformed into chance constraints with pre-defined confidence levels. In this way, relations between the aspects of reliability and optimality for the power system economic dispatch can be established, i.e. a compromise for an optimal decision can be made. A back-mapping approach and a multivariate integration method are incorporated into the CCP framework so that the probabilities of holding the constraints as well as their derivatives can be numerically computed in each iterate of the solution scheme. As the monotone relation between the dependent variable and an input random variable is a prerequisite for using the back-mapping approach, a linear approximation method is introduced to obtain these monotones in the optimization process. Results of the IEEE 9-bus test system will be presented to demonstrate the effectiveness of the proposed approaches and the scope of the chance constrained OPF.

2:30 p.m. | Ch. Mattern, P. Bretschneider (DE-Ilmenau)

Predicting pattern-based time series using models derived from statistical data compression

This paper investigates the possibility of transferring forecasting methods motivated by data compression into the domain of pattern based time series prediction. Pattern based time series are characterized by typical, repeating signal subsequences. The investigations are done on the example of short term load forecast. Statistical data compression relies on pattern matching and the forecast of future patterns' probabilities. A subclass of statistical compression algorithms, Context Mixing (CM), combines the probability estimations of several individual predictors and obtains outstanding compression performance. Statistical

compression and the prediction of pattern based time series share a similarity, i.e. the prediction of real-valued entities. Hence carrying over CM concepts to time series prediction is of interest. The outline of a CM model is constituted of several specialized submodels and a mixing function to combine the individual predictions. All components rely on discrete contexts to divide a situation into distinct classes. In order to use CM concepts in time series prediction the CM model components and the context construction are investigated. A sample of electrical load data is analyzed to identify its typical characteristics. Subsequently a CM forecasting system is derived, taking the datas' properties into account. A simulation and an evaluation of the prediction error indicate very accurate forecasts.

2:50 – 3:10 p.m. Coffee break

3:10 p.m.	Y. Bodyanskiy, P. Otto (DE-Ilmenau), A. Babenko, S. Popov (UA-Kharkov)
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Neural Network Approach to Signals' Parameters Estimation in Electric Power Systems
Monitoring and full control of electricity flows is an important factor of an effective operation of electric power systems. It provides the possibility of an on-line analysis and optimal management of electricity distribution on the basis of modern achievements of power engineering and computer sciences. Computational intelligence techniques (mostly artificial neural networks and fuzzy inference systems) are widely used in this area during the last decades. However, specific character of signals in power systems (high levels of uncertainty and nonstationarity) makes the use of traditional neural networks inefficient and pave the way for the development of specialized architectures and learning algorithms aimed at the processing of polyharmonic nonstationary signals distorted by various types of stochastic and deterministic disturbances. In this paper, new architectures of neurons, networks and algorithms for their learning in real time are proposed. The obtained results allow improving reliability and efficiency of monitoring and diagnostic systems, especially under the circumstances of faults in the electric networks and in the presence of outliers in observations.

End of Lecture Session

A3 Analysis and Synthesis to Energy Efficiency Optimisation

Time: Tuesday, 14.09.2010, 11:20 a.m.

Location: Humboldt-Building, Room 011 / Foyer

Poster Session:
Chairman: P. Bretschneider, D. Westermann (DE-Ilmenau)
M. Liersch, J. Radon, R. Nürnberg, R. Stader (DE-Konstanz)
UniversalHomeServiceGateway – a hard- and software platform as a core component for Smart Grids
<p>The „UniversalHomeServiceGateway“ (UHSG) provides a central platform for a „Smart Home“. It enables „Application Service Provider“ to provide several software components to a customer, such as Smart Metering. By implementing standardized or proprietary interfaces the UHSG can easily be integrated into existing solutions such as the Smart Metering project which exists in cooperation between HTWG Konstanz and Stadtwerke Konstanz GmbH. With a powerful 32Bit ARM processor – 400 MHz, 64 MB RAM - it is capable of running a standard Linux with Java capabilities. Additionally it supports various hardware interfaces. This allows the use of more complex technologies and frameworks – such as the Java framework OSGi. The OSGi framework is a Java framework which allows installing, starting, stopping, updating or removing components at runtime. It is possible to manage the software components on an UHSG remotely via a management portal – software components can be installed, updated or removed. The project's hardware supports the RS485 bus with a proprietary Smart Metering protocol from a previous Smart Metering project as well as the IEC62056-21 “1107” protocol. Additional interfaces provided by the hardware are wireless MBUS, XBEE and Ethernet. It also supports a S0 impulse interface which is used by many electric meters that are currently in the field.</p>

A4.2 Model-Based Process Optimisation and Control

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 013

Chairman: P. Li (DE-Ilmenau)

9:00 a.m.	D. Meisen, S. v. Klinski, D. Macos (DE-Berlin)
<p>Model-driven HMI development in the automation industry</p> <p>The underlying article describes a case study for the usage of MDD in the automation industry. A few years ago an industry partner needed a new HMI platform for their automation products that are mainly in the power conversion and automation industry. The HMI platform was to fulfill numerous requirements that are symptomatic for the ongoing changes in the automation industry. The industry partner has to cope with shorter development cycles, an increasing diversity of hard- and software platforms as well as an increasing complexity of applications. Due to the increasing use of off-the-shelf hardware, nowadays the automation hardware underlies only minor variations. In contrast the applications and the necessary HMIs must cover a wide range of products and customer-specific adjustments. Additionally, the application requirements and plant complexity increased continuously. The HMI, however, was supposed to cover this underlying complexity with easy-to-understand graphical user interfaces. In cooperation with the industry partner we developed an MDD infrastructure for the graphical modeling of HMIs to be used in a variety of automation products. The MDD infrastructure is based on the eclipse frameworks (i.e. GMF, EMF, GEF, etc.), but adopted a proprietary XML-based code generation approach. The tool chain generates rich graphical HMIs that directly interact with the micro controllers via Web Services. The developed MDD tool chain consists of a graphical modeler, a graphical definition generator and a graphical definition runtime. Using the rich-client-based graphical modeler, domain experts are capable of designing and implementing HMIs without requiring any GUI programming skills. Overall, the MDD approach helped the industry partner to cope with the new industry challenges described above and significantly shortened the development-cycle for their HMIs.</p>	
9:20 a.m.	M. Bartl, M. Kötzing, P. Li (DE-Ilmenau), C. Kaleta, S. Schuster (DE-Jena)
<p>Just-in-Time Activation of a Glycolysis Inspired Metabolic Network – Solution with a Dynamic Optimization Approach</p> <p>The application of optimization in Systems Biology can provide important insights into the regulation of metabolic pathways in microorganisms. Dynamic optimization can be employed to study the time profiles or kinetic behaviors of enzymes within a metabolic network. Since most reactions within an organism are catalyzed by enzymes, the time performance of metabolism strongly depends on the availability of these enzymes. Thus, activating a specific metabolic pathway requires a coordinated regulation of the synthesis of its enzyme components in order to reduce the time until the product of the pathway can be provided. In this work the just in time activation of a metabolic pathway will be predicted by a dynamic optimization approach. The objective is to minimize the time period in which an essential product is to be generated. In previous studies the identification of optimal enzyme profiles to activate an unbranched metabolic pathways was derived using analytical</p>	

methods like the variational calculus or Pontryagin's Maximum Principle (see e.g. [Klipp et al. 2002] or [Bartl et al. 2010]). Here we extend these results by studying a glycolysis inspired pathway which is occurring in many micro-organisms. In particular, we consider the transcriptional regulation of the metabolic network constrained by physiological boundaries during enzyme synthesis. The optimization method used for the identification is the quasi-sequential approach [Hong et al. 2006] with a moving finite element strategy to adapt the time element lengths. Several optimization scenarios with different enzyme synthesis constraints are studied. The results of the optimization indicate that a sequential synthesis of enzymes within the pathway minimizes the time toward product formation. These results are reminiscent of experiments in which a sequential activation of gene expressions in several amino acid biosynthetic pathways was observed [Zaslaver et al. 2004]. The introduction of a branching pathway leads to a qualitative new behavior in which one product of the branching reaction accumulates and is consumed later on. This leads to the idea to introduce additional constraints to restrict the osmotic pressure if the accumulation is too intensive.

9:40 a.m. | M. Fischer (DE-Jena)

Model Predictive Control of a laboratory high temperature retort furnace

In this paper a linear MPC strategy of a laboratory high temperature retort furnace is presented. In the course of a system analysis highly nonlinear static behaviour is detected. Moreover nonlinear dynamic behaviour is existent. Primary goal of the work was a predictive control strategy, which can be implemented in a PLC. For this reason a simple control strategy is developed, which needs low computing power. As a general basis the nonlinear MIMO- process is identified by means of a Multilayer Perceptron (MLP) with external dynamic. For achieving simplicity the MPC- controller works with a linear SISO- model. This internal model is achieved by consideration of specific conditions and linearization over the operating range. A further essential simplification of the MPC- controller is the avoidance of explicit constraint handling. The consideration of the constraints is achieved by an anti- windup- strategy, which is adapted for the MPC- controller. Because of the linear SISO- approximation of the process the adjustment of the MPC- controller is performed by means of qualitative aspects and simulations with the MLP- model. By usage of the a-priori available reference trajectory the velocity error can be minimized. As a result the MPC- controller offers an increased control performance in comparison with a conventional PI- controller. That is, the linear MPC- controller shows better robustness against the nonlinearities. By usage of the feedforward path of the MPC- controller considerable less velocity errors are attainable.

10:00 a.m. | J. Tamimi, P. Li (DE-Ilmenau)

Control of a Loading Bridge using Nonlinear Model predictive

Model predictive control (MPC) or receding horizon control (RHC) is considered as one of the most important control algorithms. In this paper, we apply a new nonlinear model predictive control (NMPC) approach to control a loading bridge. A multiple shooting combined with a collocation on finite elements is used to realize the NMPC. That means, the

multiple shooting algorithm is used to convert the optimal control problem to a nonlinear program (NLP) by discretizing the prediction horizon into equal subintervals and parameterizing both the control trajectories and the initial conditions of the state trajectories in each subinterval. Thus, the degree of freedom of this NLP consists of parameterized controls and initial conditions of the state trajectories in each subinterval and the system differentiable algebraic equation (DAE) model will be replaced many equality constraint. The collocation on finite elements is used to compute the state variables and their gradient at the end of each subinterval. We employ a three point collocation on each element (subinterval) and we use the Newton-Raphson method to compute the state variables. On the other hand, we use LU factorization using forward and backward substitution to solve linear system in the system sensitivities. Applying this approach to control the loading bridge with a highly nonlinear model equation shows a high accuracy and computation efficiency for the integration of the model equation. The task of control the loading bridge is to move the cart by means of the transmission belt to an arbitrary point at the metal guiding bar. In addition the movement should be carried-out with a minimum energy. The controlled loading bridge is considered to be disturbed in each feedback measurement. The numerical solution is realized in the framework of the numerical algorithm group (NAG) and IPOPT to solve the NLP problem and in C/C++ for the rest of computation.

10:20 – 10:40 Coffee break

10:40 a.m.	M. Bartl, P. Li (DE-Ilmenau), M. Pfaff, S. Töpfer, St. Schuster (DE-Jena), S. Zellmer, R. Gebhardt (DE-Leipzig)
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Model-based Optimization to Explain Liver Zonation in Nitrogen Metabolism

The paper presents a novel approach to use model-based optimization (MBO) to explain liver zonation. The approach is based on an established model [1, 2] that describes essential reactions of the nitrogen metabolism in the liver lobule. Lobules are the sub-units of the liver and consist of a periportal (pp) and a pericentral (pc) zone. Model structure and parameter identification was based on rat liver perfusion experiments [3]. The model has a two-compartment structure, one compartment for the pp and one for the pc zone. It describes for the pp zone glutamine breakdown to ammonia (enzyme: glutaminase) and ammonia detoxification to urea (carbamoyl phosphate synthetase) and for the pc zone glutamine synthesis (glutamine synthetase). A nonlinear programming algorithm was used to identify optimal activities of the enzymes that catalyse the above metabolic reactions. All these reactions were allowed to take place in each compartment, i.e. there was no pp or pc zone assumed for the MBO. The aim was to determine optimal enzyme activity distributions along the compartments. Based on the original model, biologically motivated objective functions (representing different strategies of the liver) were defined and constraints on the enzymes introduced. The MBO was first based on an objective function that solely considers ammonia minimization. The results show only activities of the enzymes for ammonia detoxification, i.e. using this function does not reflect the zonal structure. Since however ammonia detoxification to urea and regulation of glutamine are both major tasks of the liver lobule, the objective function was reformulated to reflect besides ammonia detoxification, urea formation as well as glutamine regulation. The optimal enzyme activity distribution obtained structurally reflects the pp and the pc zone of the original two-

compartment model [1, 2]. The MBO was then extended to consider 16 compartments that correspond to the average number of hepatocytes from the pp to the pc site. The identified small pc zone is experimentally well supported [4]. The MBO results obtained again support the zonation structure, indicating however a necessary further subdivision of the pp zone.

11:00 a.m. | J. Wagenpfeil, E. Arnold, F. Malchow, O. Sawodny (DE-Stuttgart)

Optimal Control of Distributed Parameters Systems on the Example of a Glass Feeder

Various technical systems are characterized by the existence of location dependent state variables. These so called distributed parameter systems are usually modelled using partial differential equations. The control of such systems often proves to be a challenging task, since it is in most cases impossible to find an analytical solution for the infinite dimensional control problem. This is particularly true if nonlinearities exist. A frequently used approach to derive a feasible control strategy is to transform the control problem into a suitable optimization problem. The resulting optimal control problem may then be solved using appropriate numerical methods.

In this work, first, different methods for optimal control based feed forward controller design are discussed. Then, a direct collocation based method as well as a multi-stage control parameterization for solving the optimal tracking problem are presented. The first method uses a full discretization of the partial differential equation, while the latter approach is based on the method of lines. Here, the partial differential equation is first spatially discretized, and the resulting system of ordinary differential equations is then optimized using a specialized numerical solver.

The presented control approaches are applied on the example of an industrial glass feeder. This feeder transports melted glass from the smelting furnace to the former. Depending on the desired end product, the glass at the output of the feeder must have a precisely defined temperature, which is adjusted via gas burners placed along the feeder. The presented optimization based control strategies are used to achieve a shift of the output temperature of the feeder. The results are then compared to an existing differential-algebraic control approach called Transport ansatz. This flatness based approach uses an m^{th} order approximation of the exact solution of the partial differential equation to compute the control input based on a given reference trajectory. Simulation results for different scenarios with and without constraints are given, and the major differences between the presented optimization based approaches and the differential algebraic approach are discussed.

12:00 noon – 1:30 p.m. Lunch break

A4.3 Model-Based Process Optimisation and Control

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 013

Chairman: Ch. Ament (DE-Ilmenau)

1:30 p.m.	G. Filaretov, A. Sh. Avshalumov (RU-Moskau)
<p>Cascade Artificial Neural Networks</p> <p>New variant of artificial neural networks (ANN), named by cascade ANN (CANN), is proposed. Such networks are formed as a cascade connection of at least two ANN, may be of different types. CANN differ from known variants of hybrid networks by organization of training process: different training samples for training of different cascades are used; these training samples are formed on a basis of results on the training ANN of a previous cascade by sorting initial sample elements and/or using some conversation of initial information. In whole the training process is realized sequentially from the first cascade to the last. The sphere of application CANN – data analysis applying to significantly heterogeneous situations, that may occur when solving of some typical tasks, such as: - classification with differently remote classes, when points of some classes are remote from each other on significant distances and so are easily separated, at the same time points of some other classes are small remote from each other and it is difficult to separate them; - classification with differently informative data and/or with variables of different types (quantitative, qualitative, ordinal, ranked); - developing a model of an object at presence of several operation modes. Possibilities of the proposed neural networks type are demonstrated with examples of the de-velopment of classifier for medical diagnostic complex, the construction of ecological model for radon content forecasting in atmosphere of mining working and - mathematical model of a unit of pharmaceutical purpose.</p>	
1:50 p.m.	A. Bulgakov, S. Zaghlul Saeed Al-Khayt (RU-Novotscherkassk)
<p>Neural Network for Non-Smooth Nonlinear Approximation</p> <p>Model-Based Process Optimisation and Control Nonlinearities are available in control systems frequently due to the nature of most physical systems. Many physical components of control systems have non-smooth nonlinear characteristics such as dead-zone, hysteresis, saturation, friction, backlash and various nonlinear relations between system variables. The adaptive control of nonlinear systems has recently made significant advances. The most common NN architectures used in nonlinear control applications are the multilayer perceptron (MLP) and the radial basis function (RBF) NN. It is known that the use of feed forward neural network with the back propagation (BP) learning algorithm causes problems with local minima, saddle points and the algorithm itself has a very slow convergence rate. Thus, its use is limited to off-line training applications. In this work, we investigated the performance of the radial basis function neural network for non-smooth nonlinear approximation. The neural net work is trained on-line to compensate the nonlinearities such as friction and backlash. The results are presented to illustrate the advantages of the proposed neural network. The Radial Basis Function NN has a dynamic structure due to the pruning strategy, thus it has convergence to the desired target, which makes it suitable for real-time on-line learning. Simulation's results show the effectiveness of the radial basis function neural network for approximation the nonlinearities such of friction and backlash.</p>	

2:10 p.m.	Y. Bodyanskiy, O. Vynokurova (UA-Kharkov), P. Otto (DE-Ilmenau), J. Sokolovskyy, O. Petryanych (UA-Lviv)
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Adaptive controller for nonlinear dynamic non-stationary stochastic plant based on real time neo-fuzzy-model

Nowadays a large number of the nonlinear dynamic non-stationary control systems synthesis methods have been developed. But implementation of such systems usually requires the knowledge of the exact control plant model, which often is a rather complex task. Considering this it seems reasonable to use the approaches based on computational intelligence approaches, notably hybrid neuro-fuzzy- and neo-fuzzy-systems. Such systems are a powerful tool for the control plant identification under current and a priori uncertainty especially in real time. For the plant identification we have used an adaptive model based on the neo-fuzzy-neuron [1], which has rather simple neuro-fuzzy architecture of the zeroth order Takagi-Sugeno-Kang neuro-fuzzy system type and is characterized by high tuning rate and simplicity of both software and hardware implementation. Using adaptive control methods the controller based on neo-fuzzy-model with generalized minimum variance and constraint on the power with the intellectual parameter definition is proposed. The advantage of the proposed controller is a convergence rate [2] increasing due to quasi linearity of its structure, which allows to control the nonlinear non-stationary processes. The experiments were carried out on the real technical task, included the process of wood desiccation modeling and control. Using the proposed adaptive controller allows to increase the quality of the wood desiccation process providing the required humidity level or the electric power consumption constraints.

2:30 p.m.	Ch. Arnold, B. Cuno (DE-Fulda), Ch. Ament (DE-Ilmenau)
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An Approach for the Control Error-Calculation Under Fuzziness

In some automation tasks the final demanded values, basically the process-variables are not defined by means of fixed set-points. They are rather based on tolerance values (ranges), thresholds, classified limits or multi-valued states. Particularly, in the area of air conditioning and climate management, only rough values of set point are available: mainly because climatic requirements are often linguistically described and provided with lack of knowledge. These characteristics suggest incorporating fuzzy-theory, using fuzzy-numbers and fuzzy-intervals to formulate set-points. This representation contains additional benefits, such as offering a transparent method considering many requirements (multi-objective goals) and linguistic hedges by fuzzy-modifiers. Furthermore, the acquisition of process-variables is rather uncertain. At a first level errors are caused by the inaccuracy of sensors. More different error sources are such as model inexactness (differences) or stochastic influences. Hence measured, observed and predicted process-variables are always vague. This uncertainty can also be described using fuzzy- numbers and fuzzy-intervals. Typical tasks of automation are based on the control error calculation (comparison of desired- and actual-values), with the question however arising how the fuzziness aspect can be taken into account; this problem is only discussed in a few papers. The submitted paper clarifies options to represent set-points and actual-values using fuzzy-theory, depicts problems in calculation of control errors and proposes a novel method. This can be applied for diagnos-

tics-, monitoring- and optimization-tasks, especially for predictive concepts. Index Terms: fuzzy decision making, predictive control strategies, multistage fuzzy control, desired-actual value comparison under fuzziness.

2:50 – 3:10 p.m. Coffee break

3:10 p.m. | S. Pan, H. Su, Y. Gu (CN-Hangzhou), P. Li (DE-Ilmenau)

Constrained State and Unknown Input Estimation for Nonlinear Singular Systems Using a URNDDR Approach

The estimation for constrained states in nonlinear singular systems is addressed using a unscented recursive nonlinear dynamic data reconciliation with unknown inputs (URNDDR-UI) approach in this paper. It is well known that the regular unscented recursive nonlinear dynamic data reconciliation (URNDDR) approach can reliably and accurately estimate the nonlinear states with bounds and other constraints, which are quite common in the chemical processes. However, when there are arbitrary unknown inputs (e.g., the deterministic disturbances which cannot be regarded as stable white noises) presented in the model equations, the regular URNDDR fails to cope with this case. In this regard, the recursive weighted least squares estimation (WLSE) is used in combination with the unscented transformation (UT) and nonlinear optimization (NO) methods to formulate the proposed URNDDR-UI approach whose major advantage is its capability of simultaneously estimating constrained states and unknown inputs in the model equations of singular systems. Simulation results demonstrate the efficiency of the proposed URNDDR-UI and indicate its potential of applications to chemical processes.

3:30 p.m. | I. Mynttinen, P. Li (DE-Ilmenau)

Reformulation methods for a hybrid parameter estimation problem

In many industrial processes switching behaviors through changes of the operating mode can occur due to external control actions as well as internal phase transitions which complicate the prediction of system output states from input states. For discontinuous nonlinear dynamic systems the relationship between input and output is not readily accessible for optimization, since discontinuities in the states and their gradients lead to difficulties for finding a solution. This is generally due to the violation of constraints. In this contribution we compare two reformulation methods which lead to a smooth representation of the problem. Discontinuities are removed by introducing a penalty term into the objective function or by replacing the instantaneous transition by a smoothing function in the model equations, respectively. The parameter estimation problem for a three-tank system with internal mode switching behaviors is taken to investigate the effectiveness of both methods. We first present the way how the original problem is modified in both cases. Then the model is implemented in Modelica and included in the optimization framework using JModelica. The parameter estimation problem is solved by the NLP-solver Ipopt. The discretization of the continuous model formulation is carried out using collocation on finite elements. For each method the dependence of the solution on the respective reformulation parameter is investigated. Solutions with appropriate reformulation parameters from both methods are compared and their suitability is discussed.

End of Lecture Session

A4 Model-Based Process Optimisation and Control

Time: Tuesday, 14.09.2010, 11:20 a.m.

Location: Humboldt-Building, Lecture Room 013/ Foyer

Poster Session:

Chairman: P. Li (DE-Ilmenau)

F. Alexey (RU-St. Petersburg)

Experience with digital microscopes

We reviewed the theoretical and practical aspects of creating digital microscopes, in which the image of the object is projected onto the electronic.

A. Pavliy, O.A. Vinogradova, A.D. Frolov, D.N. Frolov (RU-St. Petersburg)

Experience in creating elements of automated systems for quality control microobjectives

The presentation confirms possibility of an automating assembly of the micro-objectives and monitoring of the image quality of micro-objectives.

G. Filaretov, V. Eliseev

Modified Algorithm of Neural Network Control for Non-stationary Object

A task of neural network control over non-stationary dynamic object is solved. It's supposed that dynamic behavior of the object may change at arbitrary moment. Reference signal and noise are considered as random series. A traditional approach in such conditions – to use permanently active adoption algorithms for neural network controller and neural network for object identification. This leads to additional expenses during periods of steady object condition and may decrease quality of control in general. To avoid mentioned disadvantages it's proposed to activate adoption algorithms only if a significant systematic change of object behavior is detected. It can be done by comparison of observed plant output and signal from neural network object model. This detecting is realized with help of a well known statistical algorithm of cumulative sum (CUSUM), regulated for revelation the increase of variance of the identification error (-). The proposed approach was implemented and successfully tested in computer simulation experiment. Conditions of more high efficient of proposed algorithm in comparison with traditional approach were established. Questions of optimal cumulative sum and learning algorithms tuning are discussed. A method of adaptive neural network controller synthesis using described idea of using CUSUM procedure is formulated as a result of the research.

A5.2 Mobile Systems – Control

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: Th. Rauschenbach (DE-Ilmenau)

1:30 p.m.	O. Sokolov, W. Hussein, O. Sokolov (UA-Kharkov)
<p>Fuzzy control of Autonomous Quad-Rotor</p> <p>This article is devoted to control of autonomous quadrotor. High maneuverability and controllability of this flying robot especially in enclosed areas allow to generate new tasks for its motion. We propose two-level control system. The first (inner) level is a fuzzy logic rule base that control of stabilization of quadrotor according to its space parameters. The second (outer) level is used for navigation tasks according to external environment. Namely, we propose to use multi agent approach for estimation of situation of robot and making autonomous decision about its navigation to avoid of unexpected obstacles or wind. The decision making is based on fuzzy logic that allow to generate the best decision in the space of parameters. To recognize the environment we propose vision-based navigation system. Video processing allows to calculate the space parameters and Euler angles of the robot. The identification subsystem consists of block of calculation of projective transformation and estimating of coordinates of robot in 3D space. We illustrate the approach of control on the mathematical model of autonomous quadrotor that realized in MatLabSimulink. The next stage of work will involve closing the outer control loop with more intelligent functions.</p>	
1:50 p.m.	D. Goldbach, Ch. Ament (DE-Ilmenau)
<p>Stabilized Reversing With Vehicle Trailer Combinations</p> <p>Reversing with a vehicle trailer combination is difficult for unskilled drivers because the trailer has to be guided through permanent steering commands. The kinematics of such a system forces the steering commands to be in the opposite direction compared to driving forwards. A driver reversing can be assisted by controlling the angle between the longitudinal axle of the towing vehicle and the longitudinal axle of the trailer. The set value for the combination's articulation angle depends on the towing vehicle's steering angle, wheelbase and position of the hitch and the trailer's towing bar length. The trailer is steered by lateral movement of the hitch and therefore the trailer's coupling point. Based on a simple kinematics behaviour model of the combination's articulation angle a simple algorithm to generate the set value is derived. Based on the same model a towing vehicle velocity adaptive controller algorithm is derived using ackermann's formula. The algorithms were successfully tested in a prototype vehicle using rapid control prototyping equipment. As example results of reversing without steering wheel action straight with more than 20 kmh and parts of steady state skidpad testing backwards without corrective actions through the driver are shown.</p>	

2:10 p.m.	C. Zschippig, Th. Behrmann (DE-Bremen)
<p>The Intelligent Car Seat – Model Base for Comfort Control of Active Climate Seats</p> <p>To achieve optimal performance and traffic awareness, a driver has to feel comfortable in the car. One aspect for the comfort in a vehicle is the climate. Today, state-of-the-art cars feature automatically controlled climate in the passenger compartment, with individually set parameters for each car occupant. In addition, thermal comfort can be altered by manually controlled active climate seats. These seats are equipped with seat heating, typically electrical, and seat cooling, implemented using fans. The thermal environment in the car cabin changes dynamically, due to various influences like direct solar irradiation. Since the seat is controlled manually, the seat occupant has to react to the changing climate. Due to the nature of human thermal sensation, the seat occupant will react only after an uncomfortable situation has already arisen. With a comfort control implemented in the seat, uncomfortable situations like sweat accumulation in the cloths could be prevented. While the comfort sensation for static environments can be reasonably well predicted, there is still question as to how individuals percept dynamically changing thermal conditions. Which influence do the thermal control mechanisms of the human body have and how can these subjective comfort sensations be objectively measured? Can these parameters be measured non-invasively, without the car occupant having to place sensors actively onto the body? The main issue of this paper is to analyze the contribution potential of car seat climate control to the provision of a comfortable thermal environment, in the face of dynamically changing boundary conditions. To achieve this, data of sensors embedded in the active climate seat is evaluated. The limitations and necessities for further research are evaluated.</p>	
2:30 p.m.	D. Eck, S. Biedermann, K. Schilling (DE-Würzburg)
<p>Adjustment of the Hand Throttle of a Mobility Scooter for Elderly People</p> <p>Mobility is one of the biggest issues for a self-determined life, in particular for elderly people. Social participation and daily activities like shopping, errands or doctor visits requires mobility. Therefore mobility is a prerequisite to maintain autonomy and self-determination in old age. A part of the Fit4Age project is the development of a mobility scooter to support the mobility of elderly people. The mobility scooter will be equipped with drive assistance function, like obstacle avoidance, to relieve the operator from the challenging control of the vehicle. Furthermore autonomous functions, like human following, and a navigation system, adapted to the requirement of the mobility scooter will be integrated. The objective of this paper is one of the drive assistance functions: the adjustment of the hand throttle configuration. First of all, a velocity controller was integrated on the mobility scooter. Therefore the characteristics of the vehicle and the motor were simulated in Matlab to determine appropriate PI-controller parameters, later evaluated and further adapted to the mobility scooter hardware. Additionally a new regulation of the hand throttle was implemented. Originally the velocity between 0 km/h and 15 km/h ranges proportionally over the complete hand throttle. Different new regulations (e.g. 0 km/h – 3 km/h proportionally in the first 70% and the last 30% evenly between 3 km/h and 15 km/h) were implemented. The velocity controller and the different regulations of the hand throttle were evaluated and tested by several elderly people to find the best configuration. The result enables the operator an easy and safe control of the mobility scooter, especially at narrows and at slow velocities.</p>	
2:50 – 3:10 p.m. Coffee break	

3:10 p.m.	H. Renkewitz, Th. Pfützenreuter (DE-Ilmenau)
<p>A Generic Guidance System for Underwater Vehicles</p> <p>Today, it is not exceptional for an institution to own several different autonomous underwater vehicles. Despite the nice effect of having multiple platforms available, this can easily become a challenge for the user and even more for a system designer. Each vehicle is usually equipped with a native control system and hardware specific modules. The Fraunhofer Application Center System Technology in Ilmenau (Germany) currently possesses three underwater vehicles (both AUVs and remotely operated vehicle's, ROVs); another novel vessel is being developed. All vehicles are equipped with individual guidance systems. Thus, modifying and creating new software, planning missions and evaluating them has to be done in very different ways. This fact shows the necessity to develop a new software framework for underwater vehicles. It is called ConSys (short for Control System) and offers the following features:</p> <ul style="list-style-type: none"> • Vehicle independent guidance system: development of a - as far as possible - vehicle independent control system for AUVs and ROVs, including autonomous and teleoperated manipulation capabilities, • Graphical user interface: easy to use, extensible, task-oriented application for mission planning and evaluation, • Abstraction layer: complete platform-independent abstraction layer for all necessary interfaces for the running operating system, sensor and actor buses, • Software structure and communication: support of modular control systems with simple and powerful inter-process communication mechanisms. All of these features will be fully described in the paper. 	
3:30 p.m.	M. Jacobi, S. Matz, F. Schrödel (DE-Ilmenau)
<p>A Practical Workflow for AUV Control System Design</p> <p>Recently, autonomous underwater vehicles (AUVs) have gained more and more importance in performing tasks such as inspection, exploration and deep water. Many AUV missions can be only done once or without repetition. Therefore, task specific algorithms cannot be improved with experiences gained during missions; test missions and test scenarios have to be used instead. The task specific algorithms (e.g. for control and parameterization) need validation and evaluation to be function in a safe manner. We developed an environment and tools for testing and evaluating these algorithms. The development process of these specific algorithms consists of:</p> <ul style="list-style-type: none"> • Vehicle development o geometric boundaries specification • Mathematical modeling o motion equation for vehicle movements o hydrodynamics • Controlling o analysis of dynamic equations for stability etc. o controller design • Virtual Reality o sensor definition o 3d vehicle models • Test basin o integration test: hardware and software <p>All these steps are connected and influence each other. In this paper we will present an exemplary method for the controller and algorithm design using methods provided by the testing environment developed at the Fraunhofer Application Center System Technology.</p>	
<p>End of lecture session</p>	

A5.3 Mobile Systems – Path Planning

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 201

Chairman: Ch. Ament (DE-Ilmenau)

9:00 a.m.	Th. Kopfstedt, B. Steurer (DE-Überlingen)
<p>Development of an Algorithm for Convoy Tasks Fulfilled by UGVs in Partially Unpaved Terrain Using Modern Simulation Techniques</p> <p>This paper will present new highly complex simulation environments using the Microsoft Robotics Developer Studio with the simulation of cameras in combination with 3D Lasers and simulated self localization algorithms as testbed for autonomous behaviors.</p> <p>This simulation environment allows the increase of the development process and gives the chance to compare the capabilities of different algorithms under exactly the same conditions in large simulated environments considering the physical effects and the latencies of the simulated sensors including error models.</p> <p>We will present how this simulation environment is built using independent services and how this allowed us to adapt the simulation environment for different robotic systems running a Diehl BGT Defence. As an example we will present for one of our autonomous systems the development and transfer of an algorithm for object tracking and following for a convoy task from the simulation to the real system including experimental data.</p>	
9:20 a.m.	Th. Kopfstedt, B. Steurer (DE-Überlingen)
<p>Movement of an Autonomous System along Specified Waypoints with Consideration of the Terrain</p> <p>In urban environments with specified types of obstacles and a paved ground autonomous systems are already able to drive along specified waypoints and to fulfill tasks independent from a human operator. In open space with unpaved terrain, changing weather conditions and several changes of the illumination of the environment due to the movement of the sun, clouds etc. this task becomes quickly a challenging one which is not completely solved until now. Also the solution presented by us will not allow a successful movement on all kinds of terrain and in all weather conditions. But for some common weather conditions and a limited set of terrains the algorithms presented have a high chance in being successful to fulfill a waypoint navigation task.</p> <p>We will present the idea behind the concept, discuss some of the underlying algorithms in comparison with possible alternatives and show selected simulation results gathered with these algorithms.</p> <p>This includes the classification of the terrain into different types based on a fixed cell size and a specific A* derivate for the trajectory generation in real time that allows vehicle velocities up to 20 km/h.</p>	

9:40 p.m.	L. Xiao, J. Jouffroy (DK-Sønderborg)
<p>On Path Generation and Feedforward Control for a Class of Surface Sailing Vessels</p> <p>Sailing vehicles with wind as their main means of propulsion (i.e. our well-known sailboats, ships equipped with a kite or landyachts) possess a unique property that the paths they take depend on the wind direction, which, in the literature, has attracted less attention than normal vehicles propelled by propellers or thrusters have done. This paper considers the problem of motion planning and controllability for sailing vehicles representing the no-sailing zone effect in sailing. We present an extended algorithm for automatic path generation with a prescribed initial heading for a simple model of sailing vehicles going upwind, together with a feedforward controller guiding these vessels along desired trajectories of bounded curvature. Simulation results are hereby presented to illustrate the approach. Based on our previous work and inspired by the controllability analysis, we show mathematically that there always exists a wearing path linking the initial configuration to any other configurations in the space of the system for any established starting headings outside the no-go zone and for a final orientation to be decided upon. More specifically, a conventional way of path construction (i.e. by using of a sequence of straight line segments and arcs of a circle with fixed radius) is adopted here to build a feasible smooth trajectory, and we prove the existence of such paths. At the same time, a few construction results are presented as explanations.</p>	
10:00 p.m.	F. Müller, A. Gehr, A. Wenzel, A. Muth, B. Franz, Ch. Ament (DE-Ilmenau)
<p>Automatic Driving of an Outdoor Vehicular Platform using GPS and Photonic Mixer Device (PMD) Cameras</p> <p>Much research has been conducted in mobile robotics so far. The main difficulty lies in the correct perception of the environment. Various sensors are available for this task, e.g. camera, radar, lidar, sonar. Combination of these sensors in the sense of sensor fusion may lead to a more detailed picture of the environment. This paper presents a method for controlling a mobile platform on basis of the combination of information provided by GPS and information derived from vehicle sensory. The task defined for the vehicle is to automatically drive from a starting point to a goal position (both stated in WGS84 coordinate system) while circumnavigating obstacles. For this purpose, the control of the vehicle relies on the following inputs. First on the position information of a GPS sensor. Secondly on the sensor data of two photonic mixer device (PMD) cameras. Signal loss and multipath propagation of the GPS are problems and therefore have to be handled appropriately. The control of the vehicle is done by extracting road boundaries from the PMD data as additional control information. Furthermore the PMD cameras are for detecting obstacles. Test drives are used for evaluation of the control algorithm.</p>	
10:20 – 10:40 a.m. Coffee break	

10:40 a.m.	M. Eichhorn (CA-St. John's)
<p>Optimal Path Planning System in Time-Varying Environment</p> <p>This paper presents an algorithm for path planning in a time-varying environment based on graph methods. The methods presented make it possible to find an optimal path using defined requirements in a feasible time. The task of the introduced path planning algorithm using an AUV is to find a time-optimal path from a defined start position to a goal position with consideration of the time-varying ocean current. An additional consideration discussed in this paper is the determination of the optimal departure time. The solutions and algorithms presented in this paper are focused on path planning requirements for the AUV "SLOCUM" glider. These algorithms are equally applicable to other AUVs or aerial mobile autonomous systems. This paper is an abridgment of a research fellowship and has been previously published in parts in [1], [2], [3] and [4].</p>	
12:00 noon – 1:30 p.m. Lunch Break	

Poster Session:
Chairmen: M. Lemmel (DE-Bremen), Th. Rauschenbach, Ch. Ament (DE-Ilmenau)
<p>E. Einhorn (DE-Ilmenau)</p> <p>Pilot-modular robot navigation for real-world-applications Accomplishing navigational tasks like path planing, obstacle avoidance and motion planning are essential capabilities for autonomous mobile robots allowing them to offer more complex services. The E*-algorithm and the Dynamic Window Approach (DWA) have emerged as a de facto standard for path and motion planning. Based on these algorithms we present a generic and flexible solution of robot navigation that is applicable for both holonomic and non-holonomic robots. We propose a number of improvements and extensions that help to overcome some limitations of the original implementations and that are required for robots in daily operation. We introduce an adaptive Dynamic Window that allows a fine-grained control of the robot's actuators enabling the system to navigate with a high precision while reducing the computational complexity. The reduced complexity permits us to implement a novel multi-stage local planning method using cascaded Dynamic Windows that is able to plan more than one action of motion ahead. This multi-stage planning is needed by non-holonomic robots in order to get out of dead-end situations. Moreover, we present a combined topological E* path planner that allows path planning across multiple maps and therefore enables the application in buildings with different floors. We show how our solution can be used for a large variety of navigational tasks that reach from random exploration to more complex tasks like navigation to a given target, precise docking at a docking station or following a moving person. Finally, we prove the robustness of our concepts with long-term tests in different real-world scenarios like home improvement stores, supermarkets and fast food restaurants.</p>
<p>O. Katernoga, O. Shabrov (BY-Minsk)</p> <p>Study of stability analysis of control system for devices of mobile telecommunications The design of digital radio receiving systems (DRRS) of persistent signals, receiving signals from moving objects is considered. First, we analyzed of stability of the system. Input DRRS signal comes from the antenna output or amplifier of a high or intermediate frequency with different modulation formats. The system produces not only filtering and demodulation of analog narrow-band signal, but also the primary digital processing of extracted information through the ADC. DRRS in the GPS gives the results of evaluations of current navigation parameters; synchronization and demodulation of carrying oscillation; synchronization and demodulation of subcarriers and modulating them ranged harmonic oscillations; synchronization and demodulation of binary characters; measuring of the signal parameters in order to obtain tracking data and evaluate the receiving quality. Systems must have high noise immunity to work in conditions of intentional interference by suppression of</p>

narrowband station interference at minimal spectrum distortion of the receiving signal. Engineering calculation of digital closed systems of synchronization can be performed using quasicontinuous model consisting of the discriminator block and the linear part block with transfer function, which is the product of the transfer functions of a digital filter and digital synthesizer. The discriminator model consists of a differential part, a nonlinear part with a discriminatory characteristic, and the summation part, which receives the white noise and represents a circuit with constant parameters. We use the general theory of root trajectories in control of continuous systems. For the stability analysis of discrete systems the method for data control systems with time delay was applied. We designed the mathematical models of discrete systems in the form of analytical equations of the functional root godograph, which consider the form of modulation, nonlinearities of elements, ADC, the delay and distributed parameters. Geometric criteria for evaluation of the absolute stability of systems are developed. A computer-oriented method of stability analysis systems of regulation for radio receivers of mobile communications is proposed. The noise immunity of navigation receiver of complex signal is investigated.

A6 Control of Mechatronic Systems

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 204

Chairman: J. Reger (DE-Ilmenau)

9:00 a.m.	Ch. Recknagel, H. Rothe (DE-Hamburg)
Automation of Basic Measurement Tasks of the Nanometer Coordinate Measuring Machine The Nanometer-Coordinate-Measuring-Machine (NCMM) is developed for comparatively fast large area scans with high resolution. The system combines a metrological atomic force microscope (AFM) with a precise positioning system (NMM-1). The sample is moved under the probe system via the positioning system achieving a scan range of $25 \times 25 \times 5 \text{ mm}^3$ with a resolution of 0.1 nm. The automation of basic measurement tasks is critical for commercial use in nanometrology. A concept for automated measurements using a-priori-knowledge is introduced. Through the use of a-priori-knowledge measurement plans can be created offline. Dimensional markup language (DML) is used as a transfer and target format for a-priori-knowledge, measurement plans and measurement data. Using image registration in combination with an optical microscope regions of interest and markers can be identified automatically. After the optical measurement of the part coordinate system the measurement of the measurement elements with the AFM sensor of the NCMM is done. In contrast to commercial AFMs the NCMM has the possibility to do measure in non-raster-patterns and to do real coordinate measurements. In two case studies the use of the automated measurement is shown. In the first case studies the calibration of the device using VDI guideline 2656 is automated. In a second case study the characterization of a commercial nanofiltration membrane is done for the purpose of quality safety.	
9:20 a.m.	J. Reger, A. Amthor, B. Schmidt (DE-Ilmenau)
FIR-Filter Design for Derivative Estimation in a Nanopositioning System The paper is concerned with the real-time estimation of time derivatives with respect to signals subject to measurement noise. To this end, an algebraic counterpart of a weighted least squares algorithm is reformulated in order to find a tunable balance between proper noise attenuation and acceptable estimation delay. The estimator derived in this paper has the structure of an FIR filter whose coefficients may be calculated in an offline manner. Hence, the advocated model-free approach is well-apt for the derivative estimation under real-time conditions. The serviceability of the approach is demonstrated on a nanopositioning system where the carriage velocity needs to be reconstructed out of the noisy position signal.	
9:40 a.m.	K. Treichel, K. Wulff, J. Reger, St. Amthor (DE-Ilmenau)
Modelling and Identification of a High-Precision Planar Positioning System In order to meet the increasing requirements in high performance and high dimension accuracy for positioning systems, there has been active research on hovering, high-precision planar positioning systems in the past few years. While latest technology provides precise	

positioning capabilities down to the Nanometer scale, further improvements in high-precision dynamic positioning will only be possible by applying modern nonlinear control methods. This contribution constitutes the first step towards this ambitious goal by providing a detailed mathematical model of Tetra's state-of-the-art positioning system "PPS200". The "PPS200" positioning system consists of two main elements. An aerostatic guided slider carrying the load to be positioned and a stator plate with embedded coils. The slider is floating on air-bearings above the stator plate providing nearly frictionless motion. Permanent magnets are mounted at the bottom of the slider such that the magnetic field induced by the current through the coils of the stator plate results in a force (Lorentz' law) that is used as principle of propulsion. Based on physical models of these main components and their dynamical interaction we develop a thorough mathematical model of the positioning system. We identify the unknown parameters and characteristics of the physical components using data of the provided test rig. The resulting model is finally verified by measurements taken from the experimental setup.

10:00 a.m. | V. Polyakovski, S. Karpovich (BY-Minsk)

Control Algorithms of Planar Multicoordinate Positioning Systems

Control algorithms of planar multicoordinate positioning systems CONTROL OF MECHATRONIC SYSTEMS Introduction In computer-aided equipment of micro- and nanoelectronics items production multicoordinate systems of positioning configured out of several planar positioners placed on one stator which are meant for realization of technological and transport environment of production are rather perspective. In such systems planar positioners should provide required joint motion on the fixed trajectories considering possible geometrical collisions. The basic problem in control algorithms of multicoordinate positioning systems is in tracing the trajectories of motion of each of the positioners. It is desirable that it is optimum in speed, in fixed coordinate set of contact points with fixed pairwise combination of their bypass. Control algorithms Complex tracing algorithms to solve the task of multicoordinate positioning system's control are described in the paper. Based on the proposed comprehensive approach to tracing trajectories of planar positioners movements, it has been proposed a trajectories tracing algorithm for the control system of a printed-circuit boards tester when in use. According to this algorithm on each subsequent movement of positioners from point to point it's being generated the law of movements in analytical or numerical type which is accepted for realization or rejected depending on the results of calculation based on the algorithm of analysis and collisions prevention. Consequently after successful performance of the tracing realized by the proposed algorithm, trajectories of planar positioners movements are being generated as well as movement laws optimum in speed, which realization in the planar positioner control systems excludes collisions probability.

10:20 – 10:40 Coffee break

A6 Control of Mechatronic Systems

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 204

Chairman: S. Lambeck (DE-Ilmenau)

1:30 p.m.	C. Knoll, K. Röbenack (DE-Dresden)
<p>Analysis and Control of an Underactuated Pendulum</p> <p>Underactuated mechanical systems, i. e., systems whose dimension of configuration space exceeds that of the input space, represent an interesting and challenging class from the viewpoint of control theory and pose an highly active research field. Underactuated systems arise from different fields of motivation: academic demonstration examples like the inverted pendulum on a cart, originally fully actuated mechanisms with a lack of actuators due to weight saving or actuator failure and systems where full actuation is not possible or not desired for technical reasons. Our work is inspired from the problem of damping load oscillations on a container crane without moving the crab for the sake of operator comfort. As a model of such a crane we consider a mathematical planar pendulum with variable length, i.e. we assume the rope to be massless and inelastic and the load to be a mass point. This forms a simple underactuated system: The load mass has two translational degrees of freedom but there is only one control input, namely the force applied to rope. The equilibrium points of the system form a one-dimensional manifold. As the linearization about any equilibrium point is not controllable the system has to be addressed by means of nonlinear control theory. Our contribution now consists in the following: First it is shown that the system is not input-state linearizable and has a maximum relative degree of three. Then a collocated exact input-output-linearization is performed which results in a Byrnes-Isidori normal form representation of the system equations. As next step the time derivative of the total energy of the pendulum is expressed as Lie derivative along the vector fields of the normal form. Based on this a simple rule can be deduced to appropriately influence the total energy whilst keeping the rope length controlled. Subsequently, the system dynamics is projected into a subspace of the state space where the properties of the normal form can easily be exploited. This allows the design of a sliding mode control algorithm which implements the aforementioned rule. Finally, simulation results are presented and this control approach is compared to the common solution based on a control-Lyapunov function.</p>	
1:50 p.m.	H. Bönicke, Ch. Ament (DE-Ilmenau)
<p>Use of the Mechatronics Development System EasyKit for Didactical Purposes</p> <p>In today's industry an increasing amount of customer-adapted mechatronical systems is needed. For this purpose, employees with expert knowledge about the design of electronics and microcontroller software are searched for. Especially, for small companies it is difficult to find such employees. One of the main reasons can be found in the fact that young people usually get in contact with this topic just after they started to study, which is very late. It would be better, if electronics and microcontroller programming could be taught already in school, which probably would bring more students to the according degree courses. It is understandable that at normal schools such education cannot be done easily. On the one hand, this is, because at most schools the infrastructure does not exist. On the</p>	

other hand, this is, because the subject of electronics and microcontroller programming is very difficult, because both has to be learned about at the same time. The EasyKit system, which was actually created for assisting during the development process of mechatronical systems of small and medium complexity, contains a complete didactical strategy for teaching electronics and software to young people starting already at the age of 15 and 16. For people of this age a beginner's package with an electronics board was designed, containing a microcontroller and a variety of standard peripherals and interfaces. The microcontroller can be programmed by the graphical software development tool EasyLab. Besides the electronics board, an application board with a small motor, a fork light barrier and a light sensor is included. To get the basic information of microcontrollers, a web based training is delivered with the beginner's package. Besides, a teach-ware and examples of test applications are also delivered. Like this, a complete mechatronical system can be put into operation easily. Later, the development software EasyLab can be replaced by other tools like MPLAB or AVRStudio and the electronics can be replaced by own electronics. Like this it is not necessary to learn everything about electronics and microcontroller software at the same time. The beginner's package gives the schools the possibility to build up the necessary infrastructure to teach about this topic.

2:10 p.m. | U. Kreuzer, D. Gerling, J. Schwara, D. Kahl (DE-München)

A Model Reference Based Sliding Mode Approach for Parameter-Varying Systems

The proposed paper presents a Model Reference-based Sliding Mode Control in order to deal with the control of parameter varying systems. The examined system is a Permanent Magnet DC-drive, which is nominally a linear, time-invariant first order system. By dependence of the parameters of the states it turns into a linear, time-variant system of first order. Sliding-Mode Control (SMC) is known for certain robustness properties, which comes along with the drawback of high switching amplitudes and switching action. Model Reference Adaptive Control (MRAC) is used to adapt control parameters to unknown dynamics via Lyapunov-stability criteria. The SMC consists of a continuous part and a discontinuous part. While the continuous part is a feedforward control, the discontinuous part is a pure switching control. The adaptation scheme works as a load observer, so it can not distinguish between an external load or the change of a parameter. So the feedforward and switching control are both adapted to load changes and parameter variations. The switching amplitude may be weighted by the error between reference and measurement as well as by the adapted parameters. The proposed paper will first state the problem, in order to show how both named control techniques may be combined for the resulting closed-loop equations. The effectiveness of the proposed control-scheme is proven by both simulations and measurements. A proof of stability via Lyapunov-technique is given. Closing the proposed control-schemes will be judged.

2:30 p.m. | K. Meissner (DE-Wernigerode)

Design of Mechatronic Systems with High Availability in very harsh Operating Conditions

The use of mechatronic systems in very harsh environments requires a strengthened and

seamless interlocking of the individual components. This paper presents the methods and approaches that were developed during a research project for the stabilization and increase in the reliability of such systems. This includes a catalogue of measures for the mechanical and electronic design of such intensely-used systems as well as a software framework. Using the example of an inline marking system for castings, it is shown how mechatronic systems installed in harsh operating environments can be protected both constructively as well as through the use of modern control, regulation, and monitoring systems. The developed catalogue of measures is based in the first step on a questionnaire, in order to investigate the primary features of the system. Based on this questionnaire, in the second step the mechanical and electrotechnical loads were determined. Harsh operating environments can be understood as high loads with metallic and non-metallic dust, high and very high temperatures (>500°C), high electromagnetic interference, and high mechanical loads. In the third step, corresponding countermeasures can then be selected from the catalogue of measures and combined as appropriate. Similar to these measures, in a fourth step – after the initial mechanical and electrotechnical design has been completed – the necessary software components for the controlling, monitoring, and protection of the system can be selected. In the final step of the design, the overall system is examined and – through any necessary iterations of steps two to four – the interfaces between and the requirements of the individual mechatronic components are adjusted.

2:50 – 3:10 p.m. Coffee break

3:10 p.m. | R. Suzuki, N. Kobayashi (JP-Kamazawa), E. P. Hofer (DE-Ulm)

Sensorless Force Control via Internal Model Control Based Controller and Its Applications to Myoelectric Hand

The scope of this paper focuses on internal model control (IMC) based controller for sensorless force control. We develop a prototype of a myoelectric robotic hand that can hold an object with suitable grasping force. The optimal force distribution of the robotic hand when grasping an object is discussed by using a new IMC based controller. Generally force sensors, pressure sensors or additional sensors are required for detecting external force. However, this complicates mechanical structures and controller schemes for such robotic hands. To solve the problem, the disturbance estimation property of the IMC controller is pointed out. The IMC based controller has the required robustness, especially, disturbance compensation, decoupling property for the closed-loop system, and disturbance estimation for parameter perturbations. The proposed controller is applied to grasping control of a myoelectric robotic hand. The prototype of the robotic hand and bio-feedback system are also proposed. The robotic hand has no force sensor for detecting grasping objects. The operator is able to feel reflection force from objects by using the bio-feedback system. The experimental results is shown in this paper on sensorless grasping control by using the proposed controller. The robotic hand grasps a sponge as a grasping object via myoelectric signals. The operator changes level of signals “gain” or “loss” for grasping. From information of the bio-feedback system the operator controls grasping force. The results shows that the proposed controller estimates reflection force from the grasping object. The controller generates appropriate torque to the motor for grasping the sponge. The proposed research specifically emphasizes that from theoretical and

experimental findings the disturbance estimation property of the proposed controller is useful for detecting reflection force without additional sensors, e.g. force sensors or pressure sensors. The results are a further step in life supports to contribute towards the development of equipment interacting with humans.

3:30 p.m. | I. Mozgova, H.-P. Brückner, F.-W. Bach, H. Blume, T. Hassel, S.-M. Kussike, M. Bierbaum, P. Büggenam, M. Piszczek (DE-Chemnitz)

Development of a Therapeutic Device Supporting Real-Time Dynamic Vertical Force Unload

One of the priority directions of motion rehabilitation process optimization and analysis is the simultaneous application of different physical therapeutic methodologies. The regular training using therapeutic devices promotes stimulation and improvement of the muscular tonus. The general goal of the present work was the development and the evaluation of efficiency and safety performance of a designed therapeutic device, which is aimed at a patient's dynamic unloading during walking, combined with a plantar pressure storage system. The proposed devices overcomes the lack of a dynamic vertical unload force enabling the patients to walk at random speed. The suggested equipment has been developed on the base of a MintDrive-II (Baldor Electric Company) versatile intelligent drive with an integrated motion controller. Appropriate software has been created using the structured multitasking BASIC-like programming language Mint. The plantar pressure registration was realized with a computerized insole sensor system F-scan (Tekscan Inc.). The actual force measured by an external sensor is feed back to the MintDrive-II in order to assure to stay below a predefined maximal weight bearing. The developed rehabilitation system ensures: operational safety, positional adjustment, choice of unload level, automatic load control in a real-time operation mode and provides a visual feedback of the current walking process. The software interface allows downloading a patient's data for archiving, reporting or exporting as an ASCII-file for additional analysis. As part of a rehabilitation technology for the purpose of miscellaneous training conditions and of a variety of training intensity a treadmill and mechanical steps are used.

End of Lecture Session

A6 Control of Mechatronic Systems
Time: Tuesday, 14.09.2010, 3:50 p.m.
Location: Humboldt-Building, Room 204 / Foyer

Poster Session:
Chairman: S. Lambeck (DE-Ilmenau)
A.D. Frolov, O. A. Vinogradova, A.D. Pavliy, D.N. Frolov (RU-St. Petersburg, BY-Minsk)
Experience with digital microscopes Analytical Forming and Computer Simulator of Program Motions We reviewed the theoretical and practical aspects of creating digital microscopes, in which the image of the object is projected onto the electronic.

Y. Litvinau, S. Karpovich, N. Kekish (BY-Minsk)
Three degree-of-freedom movement simulator control system The simulator for implementing video synchronized three degree-of-freedom movements is considered in the paper. The mechanic part of the simulator is based on the parallel manipulator that is capable of realizing two-coordinate rotations and vertical movements. Therefore the direct and inverse kinematic problem solution concepts for parallel manipulator of a specified structure are presented. The inverse kinematic problem solution resulted in the algorithm, a core part of the control system, that connects manipulator platform position and orientation with shafts angular coordinates of three actuators. The paper describes the control system that has been developed and implemented for the simulator considered. The control system includes a commands generation program, a commands reproduction program and a hardware controller. The commands generation program renders and splits input video data into scenes, enables to set platform position and orientation for every scene, generates appropriate control commands in XML format for every scene. The commands reproduction program reads the generated control commands and interacts with the hardware controller via RS-232C interface. The hardware controller, that is Mitsubishi FX3U-48 controller, controls three actuators that run the manipulator. The principles that lay down in the control system considered can be reused during similar simulators control systems prototyping.

I. Dainiak (RU-St. Petersburg, BY-Minsk)

Analytical Forming and Computer Simulator of Program Motions

Analytical method of the forming of program motion is based on supplementing of drive system dynamic model in accordance with analytical motion program, without solving of differential equation system. To realize this approach, model of coordinate system is needed in the form of differential equations which describe dynamic state of system in phase coordinates. For the aims of analytical forming of program motion, motion features of mechatronic system are defined in the form of integral multiformity, and the solving of the inverse problems of dynamics in the general mathematical statement is coming to the building of motion equations of mechatronic system using this integral multiformity of motion features. As result, we supplement of motion equations using the given integral multiformity and then find the control functions from supplemented equation system. The problem of dynamics as a rule doesn't have unique solution. This fact allows solving the inverse problems of dynamics in combination with the problem of stability and optimality of motion; generally, any additional conditions and limitations to dynamic characteristics of motion can be taken into account. Computer simulation of program motion was carried out by methods of holonomic automated systems in MATLAB.

B 3 - FLIM - In-vitro Measurements

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: W. Becker (DE-Berlin)

9:00 a.m.	M.-A. Mycek (USA- Michigan)
Key Note Lecture: Quantitative Molecular Sensing in Live Cells via Fluorescence Lifetime Measurements The ability to rapidly characterize molecular function in vivo would be a fundamental advance in biology and medicine. Fluorescence lifetime imaging microscopy (FLIM) is a technique that uses fluorophore lifetime rather than fluorescence intensity for image contrast. Compared to fluorescence intensity-based methods, fluorescence lifetime imaging requires less calibration and/or correction for fluorophore concentration, photobleaching, and other artifacts that affect intensity measurements. FLIM has been employed to probe the micro-environments of endogenous and exogenous fluorophores, including measurements of cellular metabolic co-factors, pH, dissolved gas concentration, and molecular interactions via FRET. Several applications of FLIM for quantitative, live cell imaging will be described, including studies of metabolic function and intracellular oxygenation, FRET studies of oncogene association, and microfluidic bioreactor characterization for continuous cell culture. Accurate image analysis approaches for FLIM will also be discussed, along with new technologies and applications for clinical fluorescence lifetime sensing in tissues.	
9:50 a.m.	H. Schneckenburger (DE-Aalen)
Techniques, Applications and Relevant Light Doses of Fluorescence Lifetime Imaging Microscopy (FLIM) Methods of fluorescence lifetime imaging microscopy (FLIM) based on novel camera technology or single photon counting devices are presented and discussed in the context of physiologically relevant light doses. These doses should be kept in the range of solar irradiance with a few minutes of exposure ¹ . Applications are concentrated on measurements of protein-protein interactions in the plasma membrane of glioma cells, which play a major role in pathogenesis of Alzheimer's disease ² , as well as on a Förster resonance energy transfer (FRET) based caspase sensor for detection of apoptosis ³ . In addition, intrinsic fluorescence of free and protein bound nicotinamide adenine dinucleotide (NADH) is studied for glioblastoma as well as for less malignant cells, and generally some shortening of fluorescence lifetime is observed for the tumour cell line. This finding is presently discussed in the context of different metabolic pathways.	
10:15 a.m.	A. Chorvatova (SK-Bratislava)
Investigation of the effects of the lipid peroxidation product, 4-Hydroxynonenal (HNE), by time-resolved spectroscopy of NAD(P)H fluorescence in living cells Background: Lipid peroxidation is the major biochemical consequence of oxidative deterioration of polyunsaturated lipids in cell membranes and causes damage to membrane integrity and loss of protein function. HNE, one of the the most reactive products of the peroxi-	

duction of n-6 polyunsaturated fatty acids of membrane phospholipids, has been shown to be capable of affecting both the NADPH production by inactivating mitochondrial NADP⁺-isocitrate dehydrogenase activity, an important enzyme that strongly influences redox and energy status, as well as NADH production by inhibition of ϵ -ketoglutarate synthesis. Our goal was to investigate the effects of HNE on NAD(P)H in living cardiac cells. Methods and Results: NAD(P)H fluorescence was investigated by spectrally-resolved lifetime detection, employing Spectrally-Resolved Time-Correlated Single Photon Counting (TCSPC). Individual NAD(P)H fluorescence components were resolved by spectral linear unmixing approach. Our results revealed that HNE reduced amplitude of both, the free and the bound NAD(P)H in a concentration-dependent manner. The decrease in free/bound ratio indicate that HNE affected more importantly the free NAD(P)H component. In addition, HNE increased the percentage of oxidized nucleotides, also affecting the NADH production gradient. Interestingly, HNE strongly reduced the NAD(P)H fluorescence in cells where the NADPH-powered glutathione reductase, a key enzyme of the cellular antioxidant system, was inhibited. Conclusion: Our data indicate that HNE provokes an important cell oxidation by acting on NAD(P)H regulating systems in the heart. Understanding the precise role of oxidative processes and their products in living cells is crucial for finding new non-invasive tools for biomedical diagnostics of pathophysiological states.

10:40 a.m. | D. Strat, A. Rueck (DE-Ulm)

Spectrally resolved fluorescence lifetime imaging (SLIM) for the Global Analysis of FRET

An accepted method to analyze FRET (Förster Resonant Energy Transfer) is the Fluorescence Lifetime Imaging Microscopy (FLIM) by spatially resolving the lifetimes of the interacting molecular species. In a FRET experiment using short laser pulses, the behaviour of the donor and acceptor molecules is an indicator of the distance between the molecules¹. For acceptor molecules that are close enough to the donor molecules, an energy transfer occurs from the donor, which thus excites the acceptor molecules. The short laser pulses transfer energy to the donor molecules that become excited. Detection of the fluorescence intensity decay is done with time-correlated single photon counting (TCSPC)². Spectral resolved detection is achieved by a polychromator in the detection path and a 16-channel multianode photomultiplier tube with the appropriate routing electronics. Measuring the decrease in the fluorescence intensity from the donor molecules and the decrease in the fluorescence intensity from a mixture of donor and acceptor molecules, the fluorescence lifetime of different molecular species is calculated. Simultaneous analysis of data from more than one wavelength, has higher information content. Parameters like the concentration of interacting species, the lifetimes of the donors and of the acceptors are invariant across all the measured channels, thus making the global analysis³ a potent analysis method that offers higher signal to noise ratio (S/N) and better estimation of the required parameters.

The acceptor decay profile is solved analytically for a donor profile assumed to have sequentially a mono-exponential and a two-exponential time dependent behaviour.

The presentation discusses various possibilities which SLIM offers for improving molecular imaging in living cells, as well as successfully realized applications⁴. In this presentation, it is shown that a considerable improvement could be achieved when time-resolved and spectral-resolved techniques are incorporated, by simultaneously fitting the multidimensional datasets which result from the kinetic equations in every spectral channel. Special attention

is focused on FRET measurements with respect to protein interactions involved in Alzheimer's disease⁵.

- [1] Nam Ki Lee et al, "Accurate FRET Measurements within Single Diffusing Biomolecules Using Alternating-Laser Excitation", *Biophysical Journal* 88, 2939–2953, (2005)
- [2] Becker W, "Advanced time-correlated single photon counting techniques.", Springer Series in Chemical Physics, Springer-Verlag Berlin Heidelberg (2005).
- [3] Sergey Liptonok, Katharine M. Mullen, Jan Willem Borst, Ivo H. M. van Stokkum, Vladimir V. Apanasovich, Antonie J. W. G. Visser, "Fluorescence Lifetime Imaging Microscopy (FLIM). Data Analysis with TIMP.", *Journal of Statistical Software*, 18 (8), (2007)
- [4] A. Rück, C.H. Hülshoff, I. Kinzler, W. Becker, R. Steiner, "SLIM: A new method for molecular imaging," *Micr. Res. Tech.*, 70, 485-492 (2007).
- [5] A. Rück, F. Dolp, R. Steiner, C. Steinmetz, B. v. Einem, C.A.F. v. Arnim, "SLIM for multispectral FRET imaging," *SPIE Proceedings, Photonics West*, 6860, 68601F-1 (2008).

11:05 – 11:25 a.m. Coffee break

11:25 a.m. | Y. Miura (DE-Lübeck)

Appearance of autofluorescence in RPE cells at the rim of photocoagulation

Purpose: The effects of sub-lethal temperature increase on RPE cells by laser irradiation are of great interest. Therefore, we studied RPE cells by two-photon microscopy in order to evaluate changes of fluorescence characteristics and morphology after laser irradiation. **Methods:** RPE-choroid explants were isolated from porcine eyes and cultivated in perfusion culture system. RPE cells were irradiated by laser ($\lambda = 532$ nm; power 80 mW; spot diameter 300 μm ; irradiation time 100 ms). The tissue in the culture medium was observed with two-photon microscopy 3 hrs to 4 days after laser irradiation. Detection of autofluorescence (AF) intensity and spectrum was combined with fluorescence lifetime imaging. Results: From 3 to 48 hrs after irradiation, punctated and bright AF ($\varnothing \approx 0.5\text{-}1.5 \mu\text{m}$) different from melanin AF appeared in some cells around the coagulated area. The fluorescence intensity was maximal at $\lambda_{\text{ex}} = 730\text{-}750$ nm. Four-channel detection revealed the peak emission wavelength in $\lambda_{\text{em}} = 450\text{-}500$ nm at $\lambda_{\text{ex}} = 750$ nm. Fluorescence lifetime decay was best-fitted as a three-exponential curve ($t_1 = 0.19$ ns, $t_2 = 2.58$ ns, $t_3 = 5.23$ ns; mean lifetime 0.655 ns). This is similar to previously-reported fluorescence lifetime of A2-E, a precursor of lipofuscin. **Conclusion:** Laser photocoagulation induced the appearance of bright AF spots in RPE cells around the coagulation area. We hypothesize that this AF might result from laser-induced oxidation of phagosomes, which include undigested photoreceptor outer segments, leading to the generation of AF substance like lipofuscin. Intracellular distribution and the amount of this substance might indicate cell condition, such as, apoptotic change.

11:50 a.m. | S. Peters, M. Hammer, S. Jentsch, U. Werner, D. Schweitzer (DE-Jena)

Two-Photon Microscopy Application for ex vivo Investigation of Ocular Fundus Samples

Two-photon excited autofluorescence (TPEF) imaging of ocular tissue has recently become a promising tool in ophthalmology for diagnostic and research purposes. The feasibility and the advantages of TPEF imaging, namely deeper tissue penetration and improved high-resolution imaging of microstructures, have been lately demonstrated on human ocular samples (1-3). Furthermore, TPEF imaging has already been used to study age-related macular degeneration in the human retina (3). In general, spectroscopic properties of endogenous fluorophores in eye fundi are well known from in vitro spectrofluorometric analysis (4,5). But fluorophores, especially when it comes to fluorescence lifetimes, typically show a dependence of their fluorescence properties on environmental parameters like pH, ionic strength and quenchers. Hence, an investigation of ocular autofluorescence ideally in vivo is of utmost interest. The aim of our studies is to define space-resolved the stationary and time-resolved autofluorescence properties of endogenous fluorophores in the context of ex vivo porcine eye fundi samples by TPEF and confocal laser scanning microscopy. Therefore, porcine fundi (choroid, Bruch's membrane, RPE, and retina) were explanted in toto not later than four hours post mortem and transferred into a perfusion culture chamber, which then was mounted on the microscopic stage. In order to measure the TPEF of endogenous fluorophores in those ex vivo fundi samples, we employed an inverted laser scanning microscope (Zeiss LSM 710 NLO, Zeiss, Jena, Germany), a femtosecond Ti:Sapphire laser with 80 Mhz/140 fs laser pulses tunable from 690 to 1040 nm (Coherent Chameleon Vision I, Coherent Incorporated, Santa Clara, California) and a single photon counting Fluorescence Lifetime Imaging setup consisting of two Hybrid PMT's (HPM-100-40) in non-descanned operation and a spectral PMT (PML-16-1) (Becker & Hickl, Berlin, Germany). This studies will provide a basis and reference, respectively, for provocation experiments with cell and tissue cultures, for correlations with pathological alterations of ocular layers and perhaps for clinical in vivo diagnostics with a two-photon ophthalmoscope (6). Finally, we thank Professor J. Haueisen, Faculty of Computer Science and Automation, TU-Ilmenau for access to the microscopy facility described above.

12:15 a.m. | M. Hammer (DE-Jena)

Autofluorescence of the retina and retinal pigment epithelium under photo - oxidative stress as an in vitro model for pathogenic aspects in age - related macular degeneration

Purpose: To study the alteration of fluorophore composition, characterised by fluorescence spectra as well as -lifetimes, induced by photo - oxidative stress in cultured ocular fundi. Methods: Porcine fundi (choroid, Bruch's membrane, RPE, and retina) were explanted in toto not later than four hours post mortem and transferred into a perfusion culture chamber. The explants were perfused with DMEM, supplemented with 15% adult porcine serum, 25 mM HEPES, and 1% penicillin-streptomycin, at the retinal as well as the choroidal side and were kept at 37°C. Free radical stress was induced by supplementation of 150 μ M H₂O₂

and the specimen were exposed to blue light (0.41 mW/mm², peak wavelength: 467 nm). All samples were paralleled by non – exposed controls. The tissues were cultured up to six days. Two – photon microscopy (Zeiss LSM 710) was used for fluorescence detection, fluorescence lifetime imaging (FLIM) and spectral measurements. The morphological integrity of the tissues was examined by histology. Chloroform/Methanol extracts of the tissues were analyzed by HPLC and mass spectrometry (LC/ESI-MS). Results: Histology as well as two – photon microscopy revealed morphological integrity of the RPE. Fluorophores accumulated in granular structures in the RPE resembling lysosomes. The fluorescence spectra and lifetimes suggest the fluorescence to originate from lipofuscin. HPLC and mass spectrometry indicated the abundance of the pyridinium bisretinoid A2E, its precursors A2PE and A2PE-H₂, as well as oxidation products of these compounds in the RPE. Furthermore, an increase of fluorescence was found in the neural retina. Conclusions: Photo – oxidative stress results in the generation of all-trans-retinal derived lipofuscin components which are known to induce RPE apoptosis and retinal degeneration. These can be distinguished from other metabolic byproducts by the measurement of their fluorescence with spectral and temporal resolution.

12:40 noon – 2:00 Lunch break

B 3 - FLIM - Clinical Application

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: M.-A. Mycek (USA-Michigan)

2:00 p.m.	D. Schweitzer (DE-Jena)
<p>Key Note Lecture: Fluorescence lifetime imaging of the living human retina Purpose: To find a method for the evaluation of cellular metabolic state at the fundus. Methods: Analysing specific conditions for FLIM application, a fluorescence lifetime laser scanner ophthalmoscope was developed based on a modified Heidelberg Retina Angiograph. According to measurements on expected pure fluorophores and isolated ocular structures, the auto-fluorescence can be excited at 2 different wavelengths (448 nm, 468 nm) and detected by TCSPC technique in 2 spectral ranges (CH1=490-560 nm, CH2=560-00nm). Eye movements are compensated by online image registration. The time-resolved fluorescence intensity is approximated by a tri-exponential model function. A fit algorithm was developed which considers the layered structure of the eye. In ongoing studies lifetime measurements were performed on healthy subjects, age-related macular degeneration, retinal vessel occlusion, and diabetes mellitus. Local metabolic alterations can be demonstrated in images of lifetime, amplitudes, or relative contribution. Global changes can be found by statistical analysis in histograms of fit parameters. Results: Comparing with the fundus anatomy, the shortest component ($T_1 \approx 110$ ps, $a_1 \approx 87\%$) corresponds with retinal pigment epithelium and the middle component ($T_2 \approx 500$ps, $a_2 \approx 10\%$) with neuronal retina. The longest component ($T_3 \approx 1.5$-5 ns) is influenced by the fluorescence of the lens. Significant differences were found between healthy subjects and early AMD in T_1 (118 ± 23ps vs. 166 ± 53ps) and in T_2 (584 ± 184ps vs. 968 ± 408ps) of CH1. In diabetes, all lifetimes are elongated in comparison with normals. Conclusions: FLIM opens a new way for detection of early pathologic changes when alterations are reversible. But the interpretation of the detected changes requires the co-operation of physicians, biochemists, and physicists.</p>	
2:50 p.m.	S. Jentsch (DE-Jena)
<p>Characterization of ocular tissues measured by fluorescence and excitation spectra as well as fluorescence lifetime imaging Purpose: The aim of this study was the characterization and differentiation of ocular tissues measured by fluorescence spectra and lifetimes as well as the comparison with fluorescence parameter of pure endogenous fluorophores. Method: The ocular tissues cornea, lens, vitreous, neuronal retina, pigment epithelium, choroid, sclera and aqueous humour were separated from porcine eyes about one hour post mortem. The measurements of excitation and emission spectra were performed using the spectrometer LS 5 (Perkin Elmer). The spectra were averaged over measurements in tissues form 10. The fluorescence lifetimes were measured with a modified Scanning- Laser- Ophthalmoscope (Zeiss, Oberkochen) for picosecond excitation at 446 nm and 468 nm and determined applying the program SPCImage 2.7 (Becker/Hickl) with a bi-exponential approximation. The fluorescence lifetime parameters T_i (lifetime), A_i (amplitude) and Q_i (relative contribution) were determined. Results: The lens showed the highest fluorescence intensity. The spectral characteristics of</p>	

the ocular tissues is determined by the fluorophores NADH, FAD, collagenes, elastin, tryptophan, protoporphyrin IX, and others having partially overlapping emission spectra. NADH was probably detectable in all structures with emission maximum at 460 nm. In the same way a maximum at 530 nm was detected in all structures, which is specific for FAD. Whereas the emission spectra of the ocular tissues were similar, a discrimination was obtained by measuring the fluorescence lifetimes. The retinal pigment epithelium (RPE) and the neuronal retina significantly differ from each other considering the relative contribution Q1. The vitreous also differs from nearly all other ocular structures. Similar fluorescence lifetimes were detected in sclera, cornea and lens. Conclusion: The in-vivo fluorescence lifetime imaging (FLIM) of a human retina could be better interpreted with the acknowledgement of fluorescence parameters of each single ocular tissue.

3:15 p.m. | L. Deutsch (DE-Jena)

Ophthalmic FLIM for discrimination of diabetics and healthy subjects

Purpose: Applying ophthalmic FLIM for diagnostics of early diabetic alterations in the eye. Method: Diabetes mellitus is a systemic metabolic disease. In advanced stages, untreated diabetic alterations can lead to blindness. To choose treatment in time, the detection of earliest metabolic changes in the eye is necessary. The autofluorescence of endogenous fluorophores which characterizes the metabolic state can be detected by FLIM. FLIM measurements are performed on 93 diabetic and 34 healthy subjects. Three-exponential fit is applied for photon histograms in a short-wavelength channel Ch1:490-560 nm and in a long-wave channel Ch2 560-700 nm. In a first statistical analysis, parameters are compared which characterize the individual distribution of amplitudes, lifetimes, and relative contributions in both spectral channels. In a second comparison, sum histograms of amplitudes, lifetimes, and relative contribution for all healthy subjects and for diabetic patients are calculated according to the Holm method. Individual local alterations - especially regions of reduced metabolism - are detectable in images of the fit parameters. Results: Whereas no significant differences were found for the amplitudes, lifetimes and relative contributions are different between healthy subjects and diabetic patients. FLIM parameters are more different in CH1 than in Ch2. High significant alterations were found for T2 and T3 in Ch1 but not in T1. Conclusion: As T2 originates in the neuronal retina, diabetic alterations occur in this anatomical layer, but not in the RPE where T1 originates. Elongation of T3 is determined by accumulation of advanced glycation end-products.

3:40 – 4:00 p.m. Coffee break

Reproducibility of Ophthalmic Lifetime Mapper measurements

Purpose: To determine the reproducibility of fluorescence lifetime imaging (FLIM) measurements in ophthalmology on the basis of an evaluation of fluorescence decay photon histograms and by means of multi-exponential component fitting of detected photon distributions. **Methods:** For this study a Heidelberg Retina Angiograph was modified to measure the fluorescence lifetime at the human retina. This fluorescence lifetime mapper contains a diode laser which emits 446 nm pico-second pulses at 80 MHz repetition rate. The detection of auto-fluorescence was done in wavelength channel 1 at 490-560 nm and channel 2 at 560-700 nm by time-correlated single photon counting. The laser pulse interval was divided into 1024 time channels of 12.2 ps each. A lateral resolution of $40 \times 40 \mu\text{m}^2$ was achieved. For this study ten healthy male subjects aged between 25 and 35 years were examined. Each subject was measured twice per day (with one hour break in-between) on two days a week over three weeks resulting in a total of ten datasets per subject. Three regions (fovea centralis; a blood vessel free region of the papilla-macula-bundle; optic disc) each with a size of 15×15 pixels were manually selected and binned into a single fluorescence decay photon histogram. In those histograms the offset (background and detector dark current) was subtracted, the pre-stimulus part was removed and the maxima were normalized. A two-sample Kolmogorov-Smirnov (KS) test was performed for all unique permutations of the ten repetitive measurements separately for each spectral channel at a 5 % significance level. The decay of the fluorescence emission was approximated by a tri-exponential model function to determine the amplitudes a_1 , a_2 , a_3 and lifetimes t_1 , t_2 , t_3 in both wavelength channels. **Results:** The KS test shows that the measured photon distributions are significantly different in the short wavelength channel for about 6 % and in the long wavelength channel for about 8 % over all regions and subjects. The largest differences occur in the optic disc region (12 % on average) due to the generally low photon counts while the smallest differences occur in the macula region (1 % on average). Comparing both spectral channels with the KS test states in about 95 % of the cases different distributions proving that there is different information in both channels. The comparison of the first and the second measurement per day did not reveal significant differences. Mean values for amplitudes are $a_1=86.6\%$, $a_2=10.1\%$, $a_3=3.3\%$ and for lifetimes $t_1=106$ ps, $t_2=581$ ps, $t_3=2218$ ps in the papilla-macula bundle for channel 1 and $a_1=79.7\%$, $a_2=16.5\%$, $a_3=3.8\%$ and for lifetimes $t_1=121$ ps, $t_2=474$ ps, $t_3=1488$ ps for channel 2. The intra-individual reproducibility was different between the subjects. The best reproducibility (<1%) in all regions was detected for amplitude a_1 and the worst in most locations for a_3 (up to 30%). The typical coefficient of variation was less than 10% for the lifetimes. Because of the low number of photons, the reproducibility of lifetimes in the optic disc can be up to 37%. **Conclusions:** The reproducibility of this new method for functional diagnostics of metabolic changes allows for the reliable application of subsequent analysis and diagnosis methods. The amplitudes achieve most precise but less stable values in contrast to the lifetimes which are more stable by considerable accuracy.

4:25 p.m. | A. Dietzel (DE-Ilmenau)

Co-registration of FLIM and OCT measurements of the human eye

Purpose: The aim is to combine information between cross-sectional images (OCT) and metabolic data (FLIM).

Methods: The FLIM measurement at the human fundus was accomplished by a modified Heidelberg Retina Angiograph. Two spectral channels were used for auto-fluorescence detection with application of time-correlated single photon counting. A 30° region of the fundus was covered with a lateral resolution of 40 x 40 μm² resulting in one fluorescence intensity (FI) image per channel (150 x 150 pixel, up to several 1.000 gray scales). The cross-sectional images of the retina were acquired by a Heidelberg Spectralis OCT. For each scan an infrared image (1536 x 1536 pixel, 256 gray scales) was used to compensate eye-movements which covers a 30° area at the fundus. It was saved along with the cross-sectional scans and their positions on the infrared image. In the framework of a reproducibility study, which included ten healthy male subjects (age 25 to 35), each subject was measured ten times at the fluorescence lifetime mapper and once at the Spectralis OCT. Since the nature of both image data is very different and a non-rigid transformation is required, a particle swarm optimizer with different distance measures was designed. One was Mutual Information which is considered as the state-of-the-art distance measure and the other is known as Normal Gradient Fields. Furthermore a multiresolution approach was implemented to ensure a low number of convergence cycles.

Results: Experimental results with Mutual Information as the distance measure showed that an good level of accuracy can be achieved to register OCT images and FI images. In case of Normal Gradient Fields as the distance measure, the results showed to be more accurate. Attention should be paid to the quality of the FI images. Doubled retinal vessels caused by eye- and head-movements led to bad coregistration results in both cases.

Conclusions: The demonstrated coregistration of functional and structural data might improve future diagnostic approaches.

4:50 p.m. | M. Kaatz (DE-Saarbrücken)

In vivo diagnosis of malignant melanoma by multiphoton laser tomography

Aims: The incidence of malignant melanoma has shown a dramatic increase over the past three decades. On the one hand, patient outcome and curability depend on early diagnosis, on the other hand, only few excised melanocytic skin lesions turn out to be malignant at histopathological examination. Therefore, non-invasive diagnostic of pigmented skin lesions is of outstanding interest. In vivo multiphoton laser tomography (MLT) represents a recently developed diagnostic tool that allows non-invasive tissue imaging. Methods: In the investigation of eighty-three melanocytic skin lesions by MLT we identified distinct morphological differences in melanoma compared with melanocytic nevi. In particular, six characteristic features of malignant melanoma were specified and statistically evaluated. Furthermore, we investigated fluorescence intensity and lifetime in order to yield additional information for diagnostics of suspicious pigmented skin lesions. Results: Sensitivity values up to 95% and specificity values up to 97% were achieved for diagnostic classification. The most significant diagnostic criteria include architectural disarray of the epidermis, poorly defined keratino-

cyte cell borders as well as the presence of pleomorphic or dendritic cells. Remarkable differences in lifetime behaviour of keratinocytes in contrast to melanocytes were detected. Fluorescence lifetime distribution was found to correlate to the intracellular amount of melanin. Excitation at 800 nm shows a selectively observable fluorescence of melanin containing cells and offers the possibility of cell classification. Conclusion: Procedures of selective imaging as well as spectral fluorescence lifetime imaging by means of multiphoton laser tomography support diagnostic decisions and may improve the process of non-invasive early detection of melanoma.

End of Lecture Session

C3 Human Robot Interaction

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 202

Chairman: Ch. Schroeter (DE-Ilmenau)

1:30 p.m.	D. Kalmbach, J. Stuckert, K.-W. Neunast (DE-St. Augustin)
<p>The Acceptance of Robotic Systems by Elderly People - First Empirical Findings An Implemented of a Real-Time Experimental Setup for Robotic Teleoperation Systems This Paper presents the first major results of the project SEN-TAF (Technology-Acceptance by the elderly to increase independence/autonomy). The project aims to examine the acceptance of robotic systems for elderly people and make early recommendations of necessary features those systems should contain. Based on theoretical approaches of technology acceptance and an empirical study to examine the general need of support of the elderly we developed several scenarios of robot applications. These scenarios are then visualized in animations and simulations to check the preliminary defined acceptance model. Beside these scenarios we survey several other factors which might have an impact of the overall acceptance, e.g. the appearance of the robotic systems (humanoid vs. technical appearance) and the interaction 'mode' (speaking vs. non-speaking). In addition to these animations and simulations we survey the acceptance of the robotic dog AIBO as early placeholder for future developments in animal robotic systems which could serve as a resource against boredom. In the last step the results serve as forecasts for the market potential, in dependence of the determinants for acceptance and diffusion as well as the functions and external appearance of the robot systems. The field studies will take place in summer 2010, which enables us to present our first major findings on the IWK-Conference on September in Ilmenau.</p>	
1:50 p.m.	G.-J. Giefing (DE-Bochum)
<p>An Internet Protocol for the Brain: Toward a Unified Message Format as an Information Representation in Cognitive Robotics Autonomous robots have to create a wide variety of rivaling behaviors to accomplish different tasks in their real world environments depending on a limited set of hardware, software and energy resources. This is also common to living organisms. In cognitive robotics, embodied modules like sensors, actors and functional processing units are combined in a very flexible and dynamic way to achieve these tasks. Such modules still are not standardized. We discuss an intra-module information representation supporting the global workspace and the communication between modules by considering findings in robotics, computer networks communication, automation and results in neuroscience. We then propose a routable unified message format as an information representation for an autonomous robot. A demonstrator is presented proving the applicability of the proposed message format. Modules suitable for a humanoid robot head, e.g. an active stereo camera system, image processing, hearing and speech are task-driven integrated. A basic set of tasks have been implemented. The demonstrator incorporates augmented reality techniques with a focus on 3D stereo computer graphics to enhance the sensing capabilities of the interacting human supervisor and to simplify system introspection.</p>	

2:10 p.m.	Ch. Weinrich, St. Müller, H.-M. Groß (DE-Ilmenau)
<p>Appearance-based Person Tracking and 3D Pose Estimation of Upper-Body and Head</p> <p>The visual detection and tracking of human pose is a long-standing task with great importance to the human robot interaction. For realizing social navigation behaviors of a robot this pose information is essential. Since 2005 the Histograms of oriented Gradients (HoG) are successfully used for visual 2D full length body detection at lower scale. Robustness to texture, color and illumination as well as invariance on the body pose characterize this method. Unfortunately the orientation of a person is not detectable by HoG detectors. The contribution of this paper is the combination of fast HoG person detection with a 3D appearance model of the human upper-body to recognize the exact body pose and head orientation in real-time. In contrast to other body models which rely on texture models of the target person, the presented appearance model initially relies on edge information only and learns the color model of the target person on the fly. By means of the combination of HoG and the appearance model, we are able to overcome the initialization problem of other 3D model tracking approaches and are able to distinguish people once a model has been learned. The paper will shortly depict the well established HoG detector before the details of the modular appearance model of the upper body are presented. Here the representation of the edge model as well as the color model will be the focus of the first part of the paper followed by a description of the model fitting algorithm. The benefits of our method will be shown in real world experiments presented at the end of the paper.</p>	
2:30 p.m.	M. Volkhardt, St. Müller, Ch. Schröter, H.-M. Groß (DE-Ilmenau)
<p>Real-time Activity Recognition on a Mobile Companion Robot</p> <p>Recently, there has been an increasing research effort in supporting people in their daily routines. One special aspect in this topic is the companionship of users by mobile robots in home environments. In this scope, activity recognition can tremendously enhance the social interaction skills of a robot by respecting the user's state. As a subsequent ability the robot can adopt to the users preferences and habits. Furthermore, critical situations like falls or deviations from daily routines can be detected and analyzed. This paper presents a novel real-time capable activity recognition system on a mobile robot. For this purpose, we propose methods to continuously track the user's pose and motion. These features are further combined with structural knowledge of the environment to enable short-term activity recognition. Additional time-based rules allow the tracking of long- term activities. Using probabilistic modeling techniques and Bayesian inference, the system is able to cope with uncertainties in the given observations and reason about different activities. Experimental results on simulated and real data show the usefulness of our approach.</p>	
2:50 – 3:10 p.m. Coffee break	

3:10 p.m.	S. Drews, S. Lange, P. Protzel (D-Chemnitz)
<p>Creating a Distributed Development Environment for Unmanned Aerial Vehicles Using USARSim</p> <p>The development and testing of autonomous processes executed on highly agile robots like unmanned aerial vehicles substantially increases the demand for sophisticated simulation environments. Apart from the reduction of accident hazards, a solid simulation allows studies to be performed in noncritical environments and enables the use of software prototyping methods. USARSim (Unified System for Automation and Robotic Simulation) is an open-source high-fidelity simulation of robots, sensors and environments based on the popular middleware Unreal Engine which is used in many commercial games. Since its introduction in 2002 it has been evolved from a plain solution for search and rescue scenarios into a versatile research platform for autonomous robots. In this paper we discuss our efforts to create a dedicated simulation environment around USARSim for our autonomous mobile sensor platform "SkeyeCopter". The platform is based on a multirotor aerial vehicle - a so-called quadrocopter. Our work includes the development of a transparent software interface between the simulation and already existing software modules which allows the transition of algorithms between both - the simulated and the real robot. Furthermore we compare and evaluate the applicability of the robot simulation to design and develop image processing based controls. In particular, we validate an approach for Landing and Position Control of an Autonomous Multirotor aerial vehicle using the simulation environment.</p>	
3:30 p.m.	M. Schweitzer, Ch. Trommer, A. Karguth (DE-Ilmenau), O. von Stryk, Th. Lens, J. Kunz (DE-Darmstadt)
<p>Safe Human Interaction with the Compliant Robot Arm BioRob</p> <p>To open up a highly expanded functionality in direct cooperation with humans regarding mobile service and assistance robotics applications, as well as new applications in the field of automation in industries, the new biologically inspired, lightweight and elastic robot arm „BioRob“ offers a new kind of human machine interaction. The functional principle of the robot arm permits the system to apply forces, to estimate the weight of payload and to detect collision and touch in a similar way as the human arm. Further this technology allows a direct teach-in or a hand guided robot movement. In this paper, strategies for this novel, more flexible, easily reconfigurable and highly safe human robot interface are shown and discussed.</p>	
3:50 p.m.	R. Stricker, S. Hommel, Ch. Martin, H.-M. Groß (DE-Ilmenau)
<p>Realtime User Attention and Emotion Estimation on a Mobile Robot</p> <p>Within the scope of service robotics a natural and adaptive dialog is getting more and more important to offer intuitive interaction for users not familiar with the system. Therefore, service robots have to be aware of the people's mood and visual attention. Furthermore, robotic systems should be able to recognize simple head gestures like head shaking or</p>	

nodding as these gestures are a natural way of human communication. This paper presents a method to extract these information from image sequences containing the head of the interaction partner with the help of Active Appearance Models (AAMs). Therefore, a variant of AAM robust to illumination is fitted to a sequence of face images to get a parametric description of the user's face. The paper shows how to apply these parameters for human state estimation in terms of attention and emotion positivity. Furthermore, we show how to utilize the AAM parameters for head gesture classification.

4:10 p.m. | St. Müller, Ch. Schröter, H.-M. Groß (DE-Ilmenau)

Aspects of User Specific Dialog Adaptation for an Autonomous Robot

The paper will highlight some peculiarities of human machine dialog on an autonomous companion robot especially for elderly, cognitively impaired people, to be developed in the FP7 project CompanionAble. The central aspect is multi-modality of inputs and outputs, which is essential for a natural and intuitive interaction and allows a high degree of user adaptivity. The paper will introduce a prototypical dialog system and figure out some points of possible user adaptation. The two aspects learning of user input interpretation and generation of user specific dialog strategies will be explained in detail. Since speech recognition under several circumstances (distance, background noise, etc.) can be hard or even impossible, a robot system should also use other modalities like gestures or touch input to communicate. The dialog system has to learn the meaning/semantics of multi-modal input sequences and thus can reduce the rate of false input interpretations and annoying confirmation-correction cycles. The approach presented here is a Bayesian Network, modeling the correspondence of input events to semantics. This probability model can be learned online. One interesting aspect here is the learning paradigm, which is partly supervised and partly unsupervised based on the correlations. The second aspect of the paper is the strategy selection in order to fulfill the system's goals. Here we understand, what personality and argumentation has to be selected by the robot in order to make a user doing the right things. For selection of dialog strategies, the user's reactions on different options are also modeled by a Bayesian Network. Afterwards, a probabilistic planning algorithm is applied to determine the most promising strategy parameters. First results of experiments with elderly people using the developed system are completing the paper.

End of Lecture Session

C4 Model-Based Design of Embedded Systems

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 129

Chairman: A. Zimmermann (DE-Ilmenau)

9:00 a.m.	J. Scheufler (DE-Jena)
<p>MDD Tool Evaluation for Embedded Systems Within the Automation Domain</p> <p>The steadily increasing and hardly controllable complexity of modern software systems, as well as economic requirements like decreasing development-cycles within software development in general and the automation domain in particular raise the necessity of new engineering methods. The model driven development (MDD) approach promises to effectively handle these demands using platform-independent models of higher abstraction levels for software development, reusable transformation scripts and (automated) code generation out of these models. Within this paper the automation domain requirements onto MDD tools and their integration into a tool chain are presented. The features of modern MDD tools are correlated with the requirements of the automation domain. An interoperability matrix is presented, which enables the selection of UML-tools to be integrated into a MDD tool chain. Within a concrete case study a tool chain was set up, generating code starting with behavioral models.</p>	
9:20 a.m.	J. Werner (DE-Ilmenau)
<p>Concepts for a Model Driven Requirement Based Development Process</p> <p>The development of complex embedded systems usually is carried out by application of requirement based processes. Such processes are characterised by analysis and breakdown of textual requirements specifying the desired behaviour and other characteristics of the new system. This fact is also the main weakness because a plain textual description is not sufficient to obtain a complete and consistent image of a system. In opposition to that a completely model based process tries to describe the characteristics of a system within a formal model. The elaboration of such a formal model is carried out step by step whereas the first steps contain a high level of abstraction. In the later steps this abstraction is continuously replaced by the detailed formal description of the system. Implying an adequate modeling environment such a formal model can be used for simulation at any step of development. Thus validation and verification can be achieved much earlier. The main handicap of model based development lies in the increasing efforts in the early project stages wherein also a lot of experience of the involved developers is mandatory. This work tries to evolve concepts for a successful combination of both fundamental approaches. It shall be pointed out that restructuring requirement analysis by means of SysML models results in creating quality of specification. The application of UML models lower the risk of realising defective behaviour. Furthermore it will be shown that virtual integration in an executable cumulative model can be done for validating and verifying complex system behaviour.</p>	

9:40 a.m.	T. Jungebloud (DE-Ilmenau)
<p>Towards an Approach to Utilize Unified Modeling for Executable Specifications of Complex Systems</p> <p>Today's modeling languages like UML® (Unified Modeling Language) or SysML® (Systems Modeling Language) are well understood and frequently used by engineers of complex real-time- and embedded systems (RTES). Especially this domain has specific demands on the descriptive language used in the design process. Profiles for UML and SysML (e.g.: MARTE, UML Profile for Modeling and Analysis of Real-time and Embedded systems) tend to introduce facilities that convey aspects of scheduling, performance and time (SPT) in a standardized way. Nevertheless, a system specification in UML/SysML lacks of unified execution semantics. Such execution semantics are available in diverse domain specific simulation frameworks like MLDesigner. Moreover, especially the XML-based model description language MML (MLD Modeling Language) introduces a very similar concept to MARTE SPT called quantity-/server resources, which is mandatory for the modeling of functional and non-functional aspects of real-time- and embedded systems. In this contribution, we present an approach of modeling strategies and transformation rule sets to map UML models into MML models and vice versa. The transformation is explained in detail along with small example models to show the representation of model elements in the respective language.</p>	
10:00 a.m.	Ch. Bodenstern (DE-Ilmenau)
<p>Integrated software development of distributed automotive systems</p> <p>Over the last years methods of model based software development are widely established for design of complex systems. The design of distributed systems and the step from requirements towards first prototypes is much easier through using executable specifications. In modern automotive electrical and electronic systems a growing number of software functions have to be mapped on a given amount of electronic control units (ECU). Furthermore each ECU has very limited resources. Models based software engineering is the instrument for handling these issues. The need for a new design concept of automotive electronic systems and networks is shown by actual statistics of car break downs. In 2009 40% of all passenger car break downs were caused by electric or electronic issues (ADAC car break down statistics). Carmakers threat the lack of an adequate software design process by developing a new standard for automotive software. It`s called AUTOSAR. This standard has two main targets. First is the decoupling of hard- and software. The application is has no direct access to ECU hardware, so that it`s runnable on different ECU-types. The second innovation is a complete component based middleware which is one precondition for decoupling hard and software. The configuration of the AUTOSAR middleware is the most difficult task for carmakers changing their software development process to AUTOSAR. The main issue of the actual research project is the development of an integrated software design process using executable specifications to model the complete car within its environment, optimize the function distribution and generate the AUTOSAR middleware configuration together with the software components.</p>	
10:20 – 10:40 a.m. Coffee break	

10:40 a.m.	R. Schönefeld (DE-Ilmenau)
<p>Sequence-Based Specification as a New Kind of Modeling Embedded Systems Sequence-based specification (SbS) is a less known but powerful approach which formally specifies the software for an embedded or interactive system. The behavior of such a conceptual model of the software system (MSS) is expressible as a deterministic finite automaton with input and output (DFA/IO). The problem is to construct the state-transition function and the output function out of the functional requirements. In SbS both functions can be found by a so called enumeration schema of all possible sequences formed by all possible inputs crossing the interface(s) of the MSS and the required outputs. The paper will emphasize a new consideration of some details in the enumeration schema which support a more physical view on an MSS. It will be shown that there is an analogue between a mechanical system and a DFA/IO. That leads to interesting consequences for a software system concerning the relationship between a message (input) to the MSS and the state of the MSS and that the state carries the formal semantics of the MSS. Furthermore that for the semantics exist a "principle of least action" according to Hamilton's principle in mechanics. All these new insights offer better opportunities to find algorithms to reach a computer aided specification process.</p>	
11:00 a.m.	A. Karatkevich (P-Zielona Gora), S. Baranov (ISR-Ramat Gan)
<p>Graph Based Approach to Test Bench Constructing for Datapath Testing a datapath in a digital system such as a microprocessor or an embedded control system requires checking every possible way of sending data between the functional units at least once. Structure of connections between the units imposes some limitations on possibilities of such check. This paper considers a task of generating a test bench for given datapath, which covers every way of data sending at least once and is as short as possible. This paper presents a method in which a datapath is modeled by an oriented graph with nodes corresponding to functional units and arcs represent ways of data transfer. The task of optimal testbench generation can be then formulated as task of covering all arcs by the paths from input to output nodes of the graph with minimal total number of the arcs. Merging input and output nodes reduces the task to the Chinese Postman Problem, where the set of paths we seek can be obtained from the circuit being a solution of the CPP. The problem is complicated by the fact that the test sequences should consist of the microinstructions which may send data between several units at once and also by the fact that for different functional microoperations the units may require considering at different levels of abstraction. Modifications of the method taking it into account are considered in the paper. The proposed method is illustrated by a case study of testing a datapath of a processor unit.</p>	

11:20 a.m.	G. Łabiak (P-Zielona Gora)
<p>Some Computational Aspects of Statecharts Formal Modeling of Reactive Systems The paper presents a graphical notation for modeling of complex behavior of reactive systems. This notation, called statechart diagrams and invented by David Harel, features state-based description, concurrency and hierarchy. Other very essential characteristic of the diagrams is their very strict and formal definition, which allows to apply formal methods (e.g. based on state space characteristic function). This formal definition makes that, on one hand, statechart diagram can be directly implemented in programmable structure, and, on the other hand for example, their behavior can be analyzed against deadlock detection or can be transformed into other computational model (e.g. FSM). The paper concentrates on relations between some statechart semantic structures and their influence on the number of global states, what is very important for the computational complexity of formal methods algorithms.</p>	
11:40 a.m.	A. Bukowiec, A. Wegrzyn (P-Zielona Gora)
<p>From Modelling to Implementation of Concurrent Controllers by Means of Petri Nets, FSMs and Databases In the paper system for modeling and implementation of concurrent controllers is presented. Concurrent controllers are specified by Petri nets. Then structure of Petri nets is transformed into relational database. Based on data from database, Petri net is decomposed using symbolic method of analysis, like Thelen algorithm or coloring. Additionally the control algorithm can be checked if is well designed by checking if Petri net is bounded and live. In the result the set of finite state machines (FSMs) is received. Each FSM is implemented using methods of structural decomposition during process of logic synthesis. There is applied method of multiple encoding of microinstruction or internal states. It leads to decreased number of Boolean function realized by combinational part of FSM. The additional decoder could be implemented using embedded memory blocks. This leads to balanced usage of hardware resources of modern FPGA devices. The database is used for managing and changing the configuration of controller. It allows the remote reprogramming of whole control algorithm or only its part (one of concurrent FSMs).</p>	
12:00 noon – 1:30 p.m. Lunch	

C4 Model-Based Design of Embedded Systems

Time: Tuesday, 14.09.2010

Location: Humboldt-Building, Lecture Room 129

Chairman: A. Zimmermann (D-Ilmenau)

1:30 p.m.	D. Macos, D. Meisen, S. von Klinski (DE-Berlin)
<p>Implementation of a High Performance Embedded VM for the Java Language Integrating Optimization Aspects of Procedural and Functional Program Paradigms</p> <p>Software portability is one of the main goals in the field of modern mobile devices. Compared to other possibilities such as (1) binary source-to-source compilers and (2) template based cross compiler chains, the realization of java embedded software is a more and more used technique to achieve high portability of embedded software. The main challenge of this technique is the implementation of high performance java virtual machines (JVM) for small devices with limited hardware capabilities. Besides the functional scope reduction (achieved through the use of configurations such as CDC, CLDC and their combinations) the most important factor is the performance implementation of the following VM aspects: (a) efficient VM data structures (b) efficient environment for the interpretation of the operational semantics of the VM and (c) efficient optimization set of the VM. We implemented a VM which requires 50k of memory and whose runtime performance is comparable with the performance of natively compiled programs with the GNU C-Compiler (GCC). We investigated the main compiler optimization techniques of procedural paradigms such as peep-hole optimizations, caching, loop optimizations, etc. as well as the main compiler optimizations for functional languages: indirection nodes, director strings, dependency analysis, memo functions etc. After the evaluation of performance and memory requirements of selected optimizations, we defined the main VM optimization set which resulted in a small high performance runtime environment for the Java language. The new aspect in our approach is the adaption of specific techniques of the functional programming paradigm such as memo functions defined by John Hughes and indirection nodes used for optimizing SK combinator machines and their integration into an embedded VM. The result of our work is the possibility to realize very small java based embedded systems.</p>	
1:50 p.m.	K. Schulze (DE-Ilmenau)
<p>Wiring of Avionic Systems</p> <p>Avionic systems become more and more complex and are increasing rapidly. Flight assistant and entertainment systems need higher bandwidth. As a result, the information flow inside of an aircraft is growing. Consequently, one of the main issues is the wiring to connect the systems and the different aircraft zones with each other in an optimal way. Therefore, a method is required to keep the amount of cabling low and to get it more structured, lighter, cheaper and energy-efficient. Hence, to develop a method which implies to organise the cabling with optical fibre and copper is needed to find the optimum of network architecture and topologies. Accordingly the development of a new network architecture consisting of fibre optic associated with copper is a great step towards higher bandwidth and more ordered network architecture. To build up a network with optical components will decrease the weight of cabling instead of copper. The paper will present first solutions of a network model regarding optimal architecture, topologies and wiring methods. Hence,</p>	

there are three different points to be observed. At first, the network redundancy has to be studied and examined in simulations. Secondly, criticality and assurance level has to be considered as well as effects of failure or breakdown of network parts. Finally, performance assessment regarding "Quality of Service" and the network load has to be considered during the work.

2:10 p.m. | D. Shorin, A. Zimmermann (DE-Ilmenau)

Model-based Development of Energy-efficient Automation Systems

We present an ongoing work towards a methodology for model-based engineering of energy-efficient automation systems. Energy consumption as an increasingly important decision criterion has to be included in the search for good architectural and design alternatives. As a result of the work, new models of energy-efficient automation systems have to be developed. The methodology will have to show its contribution and industrial value by demonstrating the possible improvement for a real system design. New projects of equipment for energy saving will be developed and appropriate software will be created. As another result, we expect new methods of industrial energy consumption estimation. The first task will be a description method for energy consumption that can be simulated to evaluate and later optimize this non-functional property. An important candidate is the new UML profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE), which might have to be extended or adapted for our project. The system simulation will be carried out after a transformation into a Petri net or MLDesigner functional block model. A laboratory for testing and evaluating modelling and estimation quality of the work is being set up. A small lab plant will be realized based on the energy-controllable ATMEL microcontroller ATxmega128A1 and evaluation board. The first aim is to find the best possible control algorithm in terms of energy consumption minimum. The second aim is to examine the possibility of developing a microcontroller conception as a self-optimising system.

2:30 p.m. | F. Lohse (DE-Ilmenau)

Optimal Mapping of Functions to Architectures Using Model-Based Design

Today networked embedded systems are very complex. Factors like product lifetime, time to market, growing system requirements or additional constraints complicate system design. 60% of most critical system errors depends on formalization inaccuracy of secondary influence quantities like resource load, communication behavior, degree of networking, several functionalities, memory usage, execution time, type of architecture, topology, device count or energy consumption. An important criterion of system performance is the optimal usage of system components and resources. Thus a special problem is which functionality (sensor/actor system, calculation, data dump, storage, ...) should be processed on which architecture (operating system, CPU, driver, controller unit, ...). Keeping this factors in mind the resulting design space of system variants has to be searched for an optimal system configuration using appropriate algorithms. The problem is split into binpacking problem (optimal mapping of functions to architectures) and traveling salesman problem (best communication behavior). Therefore naturally-based heuristics are suitable. Primary source is the transformation of a given system specification into an executable model on abstract level of

detail (virtual prototype), which enables simulation, analysis and estimation in early design steps. The following optimization via system variation results in a reconfigured system. Automated model scaling, which decides the level of detail a subsystem has, could accelerate simulation and optimization speed against conventional simulation and optimization techniques. To sum up the design methodology shows all steps from abstract system description via simulation to optimization and is validated with the help of theoretical and practical examples.

2:50 – 3:10 p.m. Coffee break

End of Lecture Session

9:00 a.m.	K. Rosenbauer, K.-H. Franke, R. Nestler (DE-Ilmenau)
<p>An Insight of Current Frame and Sequence Based Non-Uniformity Correction Methods Related to Different Application Scenarios</p> <p>The spatial non-uniformities in infrared focal plane arrays (IR-FPA) due to different sensitivities of the detectors are a still not satisfactorily resolved problem on thermal imaging. Furthermore, depending on unknown environmental parameters like thermal instability of IR-FPA or dust on detector respectively lens surface the non-uniformities also vary in time. The resulting temporally non stationary fixed pattern noise (FPN) yields to degrading spatial resolution, radiometric accuracy and temperature resolvability. Due to the temporal drift a single initial calibration does not provide a permanent solution. Other calibration methods which need to interrupt periodically the thermal camera's normal operation are also less suitable. However, scene and image based non-uniformity correction (NUC) methods operate on single image or image sequences based on camera motion respectively changes in scene, and allow a continuous imaging process. This paper gives an overview of the state of the art of scene and image based non-uniformity correction methods for fixed pattern noise reduction. The presented methods derive comprehensive studies of primarily adaptive techniques based on constant statistics, kalman filter, least mean square (LMS) and recursive least square (RLS) algorithm, function interpolation and more. In particular, the applicability of the algorithms to the non-uniformity characteristic of a selected infrared camera is discussed and evaluated on real infrared data by different performance metrics published in the literature. Thereby different application scenarios like static scene and camera motion, static camera and scene changes and more are considered.</p>	
9:20 a.m.	C. Lucht, K.-H. Franke, R. Jahn, R. Nestler (DE-Ilmenau)
<p>Resolution Enhancement and Noise Reduction of Infrared Video Streams</p> <p>The images of thermographic (IR) cameras suffer from relatively small resolution and strong stochastic noise. Hence it is recommended to improve the image quality by subsequent processing steps. The so-called super-resolution is a well suited approach for image improvement of video streams. It exploits the fact, that adjacent images of a video stream contain the same object scene but they differ in "microscopic" details. These small differences can be used to multiply the image resolution. A super-resolution technique generates a new image from every few (typically four to ten) adjacent video images and consists of roughly three steps: image registration, alignment, and fusion. We have reworked and implemented some variants of super-resolution. The algorithms were tested with an IR camera of new generation. Among the above mentioned steps, the image fusion is the most flexible. Besides the merging of aligned original images, the fusion step can also implement filter mechanisms. These filters are intended to mitigate some influences of image degradation, for instance optical aberrations, diffraction, noise, and sampling. Also without such additions, the image fusion leads to considerably noise-reduced images, however the effect of resolution enhancement will be questionable. Unfortunately, it was stated that</p>	

real-time ability can only be achieved without any complex filtering in the fusion step. Nevertheless we have tested some algorithms that include an image restoration component. The gist of this component is to invert a simplified image generation process called "discrete observation model". Because the inversion without modification would result in an ill-conditioned equation system, it must be regularized. A deterministic regularization method that based on a damping term was investigated. Even without regarding the optical PSF, the restoration algorithm leads to more detailed images than the simple image fusion. Furthermore we have tested some modifications in order to improve the reduction of fixed-pattern noise.

9:40 a.m. | P. Prinke, R. Nestler, K.-H. Franke (DE-Ilmenau)

Speckle Reduction by an Adapted Geometric Filter Principle

The importance of sonographical examination rises during the last years. Ultrasound imaging is used in novel medical fields of application because of its real-time-capability and its noninvasive, nearly unarmful character compared to imaging procedures of diagnostic radiology. Some serious progress is achieved in the field of the image quality enhancement by conditioning the ultrasound-signal (e.g. THI, Focusing) for enhancing the contrast and resolution, etc.. Nevertheless an existing problem in this field of application is the appearance of the so called speckle noise pattern – a pattern caused by random interference between scattered ultrasonic waves received from inhomogeneous scattering tissue. To support the visual interpretation and the quantitative measurement of body tissues while the medical examination, real-time restoration of the ultrasound data is needed.

While many known approaches take an approximation of the speckle distribution as a basis for a mostly time-consuming data restoration step, this paper presents a novel and efficient approach based on the principle of geometric filtering. This approach is independent from a specific speckle distribution, involving simply the typical speckle appearance. Based on the powerful method of an adaptive and rapid stepwise convergence of each data point suitable to the estimated convex hull from its neighbours, many other cases of application with similar conditions are conceivable, e.g. fixed pattern noise reduction in infrared imaging. Medical images processed by the proposed filter-method are speckle reduced and fine-grained images with preserved texture.

10:00 a.m. | P. Semashko (BY-Minsk)

Segmentation of Unknown Moving Objects on Video Based on Statistical Check of Motion Model Hypotheses

Segmentation is used for extraction of interesting objects on images. Extraction of moving objects is a typical task for video surveillance systems intended for monitoring and security at roads, airports and other. In this work an extraction of a priori unknown objects on video is considered. The extraction criterion is model of object movement in a picture. The majority of known methods are based on background subtraction. Segmentation quality is reduced by camera noise, atmospheric agents (rain, snowfall, fog), changes of scene illumination conditions and background fluctuations such as vegetation rippling by wind. In this work a new segmentation method is proposed. It based on statistical checks of hypotheses of

motion models of interesting objects. For demonstration of the method the class of uniform rectilinear motion models have been chosen. However, the method can be generalized to high order models and it is limited only by computational complexity. According to the method a collection of testable hypothesis must be formed which include interested region of space of probable object trajectories. Resolution estimation is made to divide this space on minimum required number of hypothesis. Statistical synthesis of optimal processing algorithm of video sequence is made in the work. Processing result is a decision about presence or absence in selected area (pixel) of object that satisfy one of the movement model (hypothesis). Statistical analysis of segmentation errors is also made. Results of segmentation of test video are given.

10:20 – 10:40 a.m. Coffee Break

10:40 a.m. | A. Mitsiukhin, V. Nikalayenka (BY-Minsk)

Application of Hartley Descriptors

The paper presents the possible solution of the problem of description of the image object boundary by means of the discrete Hartley transform (DHT). Such problems appear when identifying and/or recognizing individual objects on the images (objects "of interest"). To reduce the volume of the array of data describing the object in certain applications (topography, ecological monitoring, analysis of medical images, etc.), it is desirable to replace a set of pixels depicting the object by the description of its boundary. Linear (one-dimensional) and two-dimensional objects can be presented in the form of dotted closed external and internal contours. For describing the object (boundary of the area – after segmentation of the images) and its external and internal characteristics (attributes) at the stage of selection of the attributes, the input counts are transformed by means of the discrete Fourier transform (DFT). In case of high dimensionality of the spatial data describing the object boundary, the processing complexity increases considerably. Unlike the DFT, the DHT kernel is expressed by real numbers. In respect to the real data of the image, all the computations are performed with real numbers. In comparison with the DFT, the finding of coordinates of the points describing the boundary by means of the DHT requires half as many real multiplicative operations to be performed. It saves the computational costs and makes the signal processing easier. One of the ways for reducing the computational complexity consists in eliminating the spatial redundancy and reducing the number of attributes to be analyzed. The DHT has been also used for reducing the dimensionality of transform. It provides even more practical gain in computational and temporal resources. The transform dimensionality reduction is implemented based on the dispersion (zonal) or threshold principle of filtration of the Hartley transforms [1]. Restoring the object area boundaries is implemented by means of the inverse DHT from the truncated sequences of transforms. After performing the rounding operation, we obtain the values of the coordinates describing the boundary shape. The comparative results for comparison of the accuracy of description of the object boundary are presented.

11:00 a.m.	U. Fohry (DE-Jena)
<p>A Method of Nonlinear System Optimization Based on Hybrid Evolutionary Computation Techniques and Its Application for Image Classification</p> <p>This paper presents a general method using a hybrid evolutionary search strategy to support design and optimization of nonlinear systems. Depending on the task like system identification, classification or process control a defined quality criterion of the system is gradually improved in an experimental manner. The optimization variables consist of chosen parameters and structure elements of the system. The objective function may be topographically complex and containing local suboptima. Therefore a global search method is used, that incorporates gradient-based optimization algorithms and derivativefree local search strategies into a evolutionary algorithm. The aim of the hybridization is to improve the efficiency in local finetuning, while maintaining the global search behaviour. It is shown, how the introduced method can be used for databased learning systems especially to solve a recognition problem. Therefor examples of objects and its right classification are available. Thus the parameter of the recognition system can be determined by gradient-based optimization according to the principle of supervised learning. The extraction of relevant features of the object as well as the determination of structure and initial parameters of the recognition system are realized by a superordinate evolution-based search method. Using this concept for image classification, the feature vector are chosen by the algorithm from a set of calculated parameters based on gray-level values and texture of the image. Experimental results are presented and it is refered, how this method was used for aliveness detection of fingerprints using multiple static features.</p>	
11:20 a.m.	T. Koch, R. Nestler, T. Kubertschak (DE-Ilmenau)
<p>The Advantage of Segment-Based Classification of Multi-Modal, Multi-Temporal and High-Resolution Satellite Images</p> <p>The automatic generation of land use / land cover information from multimodal satellite image data is a high challenging task. Due to the high temporally variability of several phenological and biological parameters between different vegetation types, a multi-temporal investigation arise better discernibility among various classes. Furthermore, the synergetic use of information of various modalities reaches into more increase of classification quality. Only related to the classification step the level of difficulty results from complex shaped class regions in feature spaces of high dimension. This requires classification algorithms with a high degree of freedom regarding to the class definition or the shaping of separation planes (in the feature domain). In addition a limited amount of training samples per class must be considered. The approach, presented in this paper, based on a per-segment classification. Asuitable classification method is closely connected with an efficient and powerful algorithm for the foregoing segmentation. Those segmentation and classification methods are components of the automated processing-pipeline, which will be developed inside the project ENVILAND-2. The interim results, arises from that project, where presented and discussed.</p>	
12:00 noon – 1:30 p.m. Lunch	

1:30 p.m.	J. Bosch, F. Klett (DE-Ilmenau)
<p>Safe Human-Robot Cooperation Based on 3D-Surveillance</p> <p>The increasing need of a closer cooperation between human and robots in industrial environments requires the appropriate handling of the danger situations that arise in the shared working spaces. The authors present a system which predicts and controls such situations, in order to ensure the safety of the workers while preserving the highest possible efficiency. The system is based on the fusion of the information from several sources, including stereo cameras used for monitoring the whole working space, and cameras used for controlling the specially dangerous areas (such as the surroundings of the gripper). The information from the stereo cameras is processed in order to build a 3D model of the scene, which is then used to compute the distance and relative velocity between the robot and humans. These data are stored and used to predict future hazardous situations, which are solved by appropriately reacting on the behaviour pattern of the robot. Additionally, the authors present a tool that serves to pre-select the most appropriate configuration of the system, according to the needs and characteristics of the use case to be applied. The amount and type of cameras, as well as their position and direction can be configured, and the degree of visibility of each of the regions in the working space is calculated, in terms of the number of cameras which can view them.</p>	
1:50 p.m.	D. Kapusi, P. Prinke, R. Jahn, K.-H. Franke, R. Nestler
<p>Geometric and Colorimetric Calibration For Multiview Camera Adjustments</p> <p>In modern computer vision, the sophisticated task of camera based object identification and tracking has a great application field, such as the autonomous observation of robot workspaces to deal safely with human interaction. Using multiple cameras increases redundancy, so robustness and allows achieving three-dimensional data of the objects of interest. Therefore, the camera parameters and their relative positions to each other have to be determined beforehand. To facilitate the correspondence-searching task from different points of view the optical sensors have to be calibrated to a unified color representation. In this article, a plane chessboard target with integrated color markers acts as the calibration reference for gathering the intrinsic and extrinsic camera parameters by means of subpixel accurate edge detection and the color transformation parameters at one go. The statistical uncertainty of the determined parameters decreases with the repeating of the calibration procedure at multiple target poses. The resulting calibration parameters enable the correction of lens distortions, the rectification of stereo images, the bundle adjustment and the color correction.</p>	

2:10 p.m.	H. Kantardshieffa (DE-Dresden)
<p>Technology of 3D Data Transformation for Interactive Virtual Building Infrastructure Models</p> <p>The development of an interactive virtual three-dimensional building infrastructure model implies a multi-level data transformation. The main focus of the proposed technology lies on three-dimensional data of the building form (carcass and development) as well as its infrastructure, which includes the inventory and the components of the technical building equipment such as heating, sanitary and electrical installations. The goal of the transformation is to provide different types of user-orientated final applications. The technology represents a pipeline where the 3D data is handled and transformed in a certain processing sequence. The 3D data is read in by different compatible systems and output in a transformed manner for further processing. Thus, an optimum efficiency is obtained regarding to the transfer and loading time of the final application. Each phase of the technology contains one of the main procedures such as generating, transforming and optimizing of 3D data. Transformation procedures are realised directly within the involved CAD systems such as Allplan, AutoCAD Architecture and AutoCAD MEP or implemented separately in C++ and CLisp. Raw data is imported from external systems. Several systems can be applied in each individual phase of the processing pipeline as well as skipped completely. Interfaces represent important key elements of the technology. The use of the interfaces DXF and IFC enables an efficient 3D data exchange between the various systems. Final applications with dynamic (VRML) and static (3D PDF) user interaction are supported. They are used for three-dimensional information and management purposes of building infrastructures.</p>	
2:30 p.m.	M. Schneider, D. Fey (DE-Erlangen)
<p>Implementation of an Error-Robust Bucket-Method Algorithm for Elaboration of White Light Interferometry Data on GPGPUs</p> <p>In industrial image processing the analysis of manufactured object surfaces is gaining more and more importance. One of the common and important scanning methods is the white light interferometry - height maps for an objects surface are obtained through object scanning with a white light beam. During the scan occurred interferences are taken by a camera and sent for analysis to a processing device. Depending on the captured interference pictures resolution and to be captured pictures count, requirements for memory space and computational power could be enormous. Thus, a preprocessing data amount reduction step is introduced. In this step for each pixel an approximation of the actually height is calculated and the so called range about center of interference is extracted. An efficient industrial manufacturing process requires delay-free surface analysis; therefore the preprocessing and the actual height computation step should be elaborated as fast as possible. Because the occurred interferences are independent for pixels of the same picture and the only dependence exists between correspondent pixels of successive pictures the complete processing step could be easily parallelized. Conventional multi-core processor systems are one possibility to gain a performance boost by partitioning the captured pictures and assigning the partitions to processor nodes. But parallel to the elaboration process of measurement data, some other external processes are also using resources on such systems.</p>	

Therefore available memory and processing resources have to be shared between all running processes. Thus, the performance gain is reduced. Recently, GPGPUs have attracted the attention of HPC community and manufacturing industry as co-processors, because of their peak compute capability and high memory bandwidth, compared to conventional CPUs. With the advantage of having their own memory, the possibility of running many hundreds of threads parallel to another, GPGPUs are perfectly suited for massive-parallel applications like those in white light interferometry data analysis. In this article an efficient implementation of the error-robust five-bucket method for the white light interferometry data analysis preprocessing step, using nVidia's CUDA technology, is presented.

2:50 – 3:10 p.m. Coffee Break

3:10 p.m. | M. Mashi, Ch. Ament (DE-Ilmenau)

Knowledge Based Systems for Pattern Recognition Allow Automated Process Stabilization in Laser Etching

Knowledge based systems for pattern recognition allow automated process stabilization in laser etching Authors: M. Mashi, C. Ament Abstract: Laser etching is a novel surface processing technique for metallic materials. Especially rigid materials as used for micro tools can be processed with this method. This process is controlled by several parameter, e.g. laser beam power, laser beam focus, material feed, flow of surrounding reactant, which depend on environmental conditions as temperature. Therefore, the process is very difficult to control, which hinders the introduction of this method into an industrial application. In our contribution a pattern recognition approach is presented, which helps stabilizing process quality: For process calibration a material probe with a number of grooves with fixed sets of parameters is produced. Then, the probe surface is optically measured and the obtained data is provided to the algorithm. It is able to localize the grooves automatically. For this purpose, two methods of machine learning are deployed. First is nearest neighbour method, second is clustering. Due to noise it is difficult to decide which a groove is and which is not. A knowledge based system is used for this decision. The algorithm allows adaptive behaviour to different probe topologies. After groove recognition, the depth and width of the groove is identified. These parameters can be provided to the automated machine calibration.

3:30 p.m. | M. Blau, G. Linß, M. Rosenberger, M. Schellhorn, A. Göpfert (DE-Ilmenau)

Resource-Friendly Configuration Interface for Image Sensors on Field Programmable Gate Arrays

The usage of field-programmable gate arrays (FPGA) for real-time processing of image data fitted to the image sensor relieves the indicating computer system significantly. E.g. filter operations or specific image manipulation can be realized in the camera unit itself. The biggest effort of this system is the possibility of parallel data handling of partial calculations inside the FPGA. In order to be able to change filter parameters or to enable or disable filters very fast it is useful to control the FPGA via an internal interface. So a complex recon-

figuration of the FPGA is no longer necessary. To transmit appropriate control-commands to the FPGA a control bus is needed. An inter-integrated circuit bus (I²C-Bus) would be particularly good because of its simple construction and the fact that it is already included in most image sensors. By using a new intellectual property core (IP-core), which includes the function of the I²C-Slave-Controller, it is possible to provide an adequate and reliable bus-controller. The I²C-Slave-Controller is executable by itself and does not require a soft-core processor. Received data and data to be sent is stored in a register which is variable in length (depending on its usage). Thereby the integration in existing VHDL-projects is easier. The controller has the ability to restart itself in case of error, so a high level of reliability is assured.

End of Lecture Session

C7 Image Processing, Image Analysis and Computer Vision

Time: Tuesday, 14.09.2010, 3:50 p.m.

Location: Humboldt-Building, Lecture Room 012/ Foyer

Poster Session:
Chairman: T. Machleidt (DE-Ilmenau)
A. Tamelo, V. Muravev, D. Molodkin (BY-Minsk)
Improving images at radiovision in millimetric wave length Illumination of the latent objects at formation images in millimetric and submillimetric (mm and smm) ranges of lengths of waves is necessary owing to small contrast, especially in the closed premises. Now importance of the decision of these questions has increased because of working out of technologies of multielement sensor controls of mm of a range, and also thanks to constantly increasing value practical use methods and systems of formation of images. Active illumination of observable objects allows to solve a problem of low contrast of passive (radiometric) images in mm range, and also provides transfer on an intake of the computer analysis (CA) essentially great volumes of the information about masked objects, than what can be received by means of use traditional radiometric CA. Various approaches to reception of active (highlighted) images of sufficient visual quality and the information maintenance in various frequency ranges, beginning from microwave (30 GHz) and to smm a range (300 GHz), are described in variety of works. On image distortion in mm and smm ranges considerable influence renders spatial effect of Gibbs. Theoretically also possibilities of synthesising of images high visual qualities in wide (mm and smm) a range of lengths of waves are experimentally shown. In the used scheme of multifrequency formation of images there are no devices for destruction spatial coherent radiations, and radiation changing on frequency directly shines objects in a subject plane (at normal falling of a flat shining wave on a plane). Thus as a source of radiation changing on frequency the lamps of a return wave blocking a range of 52-119 GHz were used. Test objects masked the teflon plates homogeneous for a thickness, not allowing to observe objects in visible light. Distinctive features of quasioptical display in mm a range of real objects with the considered spatial sizes are defined by fundamental bases of formation of coherent images which for range mm start to get the important practical value. The synthesised image received as a result of total accumulation of signals of five unifrequent images adequately enough displays as spatial structure, and brightness distribution in observable object, though and with contrast decrease.
A. Göpfert, M. Rückwardt, M. Rosenberger, M. Correns, M. Schellhorn, G. Linß (DE-Ilmenau)
A new inner 360° measurement procedure for three-dimensional geometrical measurements Inspection and measurement of geometrical quantities is a wide complex field. An example is three dimensional measurement of the groove from spectacle frames. Every groove is an undercut in material of the spectacle frame and therefore the direct optical path of coordinate measuring machines is blocked. A known measurement procedure is a combination of optical measurement and a plane mirror for beam deflection. Disadvantages of this method

are a limited field of view and also a long testing time. A solution is a cone mirror in combination with a high resolution camera-system. With this kind of beam deflection a simultaneous measurement of 360° is possible. The angle of the frame in polar coordinates is given by special image detection algorithms and backtracking of the form of the cone mirror. The distance of the associated measuring point can be detected by an autofocus for every detected point in the image. This combination of camera-system, beam deflection and software algorithms is an advancement in speeding up optical measurement of spectacle frames.

M. Rückwardt, A. Göpfert, M. Schellhorn, M. Correns, M. Rosenberger, G. Linß (DE-Ilmenau)

A modern inside optical detection and measuring proceeding for for the three-dimensional ground of a groove

Accurate measuring of spectacle frames is an important field of quality assurance for opticians and their customers. Different supplier for spectacle frames and a number of measuring methods are available on the market but all of them are tactile ones. In this paper there will be a short overview on a possible optical measuring method for detecting the groove of a spectacle frame. The main challenge for an optical measuring machine is the blocked optical path, because the device under test is located behind an undercut. In this case it is necessary to deflect the beam of the machine. In this study it is done with a rotating plane mirror. In the next step the difficulties of machine vision connecting to the spectacle frame are explained and some first results are given. But the main focus of this paper is on the image processing for finding stable measuring points on the ground of the groove of the spectacle frame. Therefore the demand is discussed of several steps of contour tracking for following the frame with its obstacle. Also the different filters and their combination for finding the measuring points is explained. Finally a three dimensional curve of the groove of the spectacle frame is spent.

D. Swarat, H.-G. Lipinski (DE-Dortmund), M. Wiemann (DE-Marl)

Monte Carlo Simulation of nanoparticle tracking under cell culture conditions studied by image based analysis

Nanoparticles (NP) are increasingly important for industrial and medical applications. However, some clinical findings suggest a possible health hazard of NP, prompting the examination of NP in cell culture experiments, where the behaviour of NP (changes of shape or size by agglomeration) needs to be described. To visualize NP within the culture media we use the NanoSight™ device which optically tracks the Brownian motion of NP illuminated by a specially configured laser beam. Motion of NP was captured as a sequence of images, from which NP light scattering intensity can be derived and particle size can be computed using the Stokes-Einstein relation. Since the Nano-Sight™ method reduces the Brownian motion from three to two spatial dimensions, we studied the influence of this reduction on the calculation of NP size by a Monte Carlo model which simulated the Brownian motions of NP in a virtual liquid. Illumination, scattering, and particle motion of the virtual scene were adapted to real measurements. Image sequences derived from virtual scenes were analysed in three and two spatial dimensions according to the NanoSight™ method. We found that the 3D simulation model matched the experimental situation. Furthermore the created

simulation can be used to get superior results about the spatial dimension reduction effect. Using the simulation it is possible to locate each single particle and to identify any particle at any time, especially in cases of collision, agglomeration or optical interference. Therefore, parameters of each particle such as illumination, scattering, and particle motion can be obtained from the simulation scene more accurately than from 2D original data.

Conference Programme

Academic Gala Concert

14.09.2010, 8:00 p.m.
Ilmenau's Festival Hall

Programme

Philharmonic Orchestra Jena

* **Wolfgang Amadeus Mozart:**
Overture to: "The Impresario" KV 486

* **Robert Schumann:**
Concert for Piano and Orchestra A minor op. 54

* **Ludwig van Beethoven:**
Symphony No 2 D major op. 36

Pianist Ragna Schirmer

Conductor Marco Comin

Admission 10 EUR

B2 Inverse Problems and Biosignal Processing 1

Time: Wednesday, 15.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: J. Hauseisen (DE-Ilmenau)

9:00 a.m.	R. Eichardt, J. Hauseisen (DE-Ilmenau)
<p>Evaluation of the Effect of Sensor Variations on the Condition of the Magnetostatic Linear Inverse Problem</p> <p>We evaluate in this study the influence of random variations of sensor orientations on the condition of the linear inverse problem in magnetostatics. Sensor arrays with one and two layers of perfectly in parallel aligned mono- and three-axial sensors are compared to similar arrays but with randomly varied sensor directions. The variations of the sensor directions are obtained by normally distributed random rotations about X, Y and Z-axis with standard deviations for the rotation angles between 0.05 and 25 degree. The source space is modelled by four different regular grids of dipoles that carry between 100 and 1350 source positions in one, three, or six layers. As evaluation criterion, the condition numbers of the related lead field matrices are used. Our results reveal that even small variations of the sensor orientations by 0.05 degree lead for mono-axial sensor arrays to a considerable improvement of the condition of the linear inverse problem. Larger variations improve the condition further. Furthermore, our findings indicate that also small variations of the sensor Z-positions of planar mono-axial arrays, in our case between 2 mm and 2 cm, can lead to a better condition of the magnetostatic linear inverse problem.</p>	
9:20 a.m.	D. Baumgarten, J. Hauseisen (DE-Ilmenau), F. Wiekhorst, U. Steinhoff, L. Trahms (DE-Berlin)
<p>Characterization and optimization of the cylindric 18 channel SQUID scanner in terms of source reconstruction performance</p> <p>Recently, PTB completed a stand-alone multichannel SQUID scanner. In this device, 18 SQUIDs measuring the radial field component are equally distributed on a circumference around the measurement object. Additionally, a superconducting Nyobium cylinder shields outer magnetic field disturbances. The device is designed to obtain data for quantification, localization and imaging of magnetic sources in biological systems. Possible applications are the detection of magnetic nanoparticle accumulations or magnetocardiography in small animals. In this paper, we investigate the performance of linear and non-linear source reconstruction algorithms on data simulated using the described sensor system. Additionally, synthetic sensor setups with the given positions and their sensors tilted out of the radial direction were analyzed. The target functions for magnetic dipole fit methods were estimated by computing the difference between a given source field and the field of a dipole moved through the source space and analyzed for different tilting angles. For a more general evaluation, the condition number of the leadfield matrix was studied. This matrix describes the geometric relation of possible source points and the sensor position; its condition number serves as a measure for the ill-posedness of the inverse problem. For comparison of our simulation results to measurement data, we also took into account the effect of the superconducting shield. Our investigations show more convenient target functions and a decreasing condition number when tilting the sensors out of the radial direction. This indicates a less ill-posed inverse problem compared to the given sensor setup.</p>	

9:40 a.m. | S. Biller, D. Baumgarten, J. Haueisen (DE-Ilmenau)

New magnetic marker design for Magnetic Marker Monitoring with magnetoresistive sensors

The physiologic behavior of the gastrointestinal tract (GI-Tract) is of high relevance for the diagnosis of functional disorders as well as for pharmaceutical research. The technique of Magnetic Marker Monitoring (MMM) has high potential to determine the motility of the GI-Tract and to observe the dissolution of pharmaceuticals. After ingestion of a magnetically marked tablet the magnetic field outside the patient is measured using sensitive sensors and the behavior of the marker is analyzed continuously. Current markers mostly contain magnetized Magnetite as a magnetic label which produces very weak fields. Due to this fact, measurements are performed using Superconducting Quantum Interference Devices in shielded environment. For a wider class of applications, stronger magnetic labels and more flexible recording conditions are required. We designed a new magnetic marker which allows for recordings of the disintegration with magnetoresistive sensors. The novel marker is composed of one permanent magnet and a compartment of iron powder. The iron powder is positioned only at one side of the magnet to form a magnetically instable configuration. During dissolution the iron powder reallocates and encloses the magnet, thus altering the external magnetic field. The feasibility of the novel design was tested by attaching iron powder fully surrounding a magnet and measuring the magnetic induction. Additional, pharmaceutical capsules were prepared with the magnetic components and the magnetic field was measured before and after dissolution. The external magnetic field was quantified at different distances and orientations using a fluxgate sensor in both experimental setups. The proof of principle showed a significantly reduced magnetic field after attaching the iron powder to the magnet. The field decreases by 20% to 30% in all investigated distances and orientations. The prepared pharmaceutical capsules produce a magnetic induction in the range of some μT . During dissolution the iron powder reallocated around the magnet and the magnetic induction was decreased between 13% and 21%. The results indicate that the novel marker design is well suited for MMM using less sensitive sensor technologies. This study was partly funded by the German Research Council (GRK 1567/1).

10:00 a.m. | A. Halbleib, D. Strohmeier, M. Gratkowski, J. Haueisen (DE-Ilmenau)

Source Localization Algorithm based on Topographic Matching Pursuit

Spatio-temporal decomposition methods in combination with source localization algorithms can contribute to an improved description and allocation of neural activity from electrical and magnetic multichannel measurements to underlying generators. We introduce a new algorithm, which combines Topographic Matching Pursuit (TMP) as spatio-temporal decomposition method and dipole-source localization, thus we extend the equivalent current dipole model with new parameters. The single channel Matching Pursuit (MP) iteratively creates an approximation of signals with a sum of weighted time-frequency representations called atoms, TMP is a multi-channel extension to the standard MP. In comparison to a hitherto published Multichannel Matching Pursuit (MMP) source localization the new algorithm shows, for a mirrored-dipole configuration, higher Goodness-of-Fit values, if temporal asynchrony exists in the EEG-channels. The new algorithm is applied to EEG-data obtained from a photic driving experiment with eleven volunteers. We show that the temporal asyn-

chrony in the various EEG-channels is captured by the new algorithm and transformed into the phase parameters of the extended mirrored-dipole model. The thus won information of the phase relations is interpreted as the phase parameter of the underlying neural generator. We show in particular that not only the response frequencies but also the phases of the neural sources depend on the stimulation frequency. We conclude that the suggested algorithm is more appropriate for source reconstruction in case of temporal asynchrony than MMP-based procedures used so far.

10:20 – 10:40 Coffee break

10:40 a.m. | U. Graichen, R. Eichardt, J. Haueisen (DE-Ilmenau)

Spatial frequency analysis of cortical surfaces

The human brain exhibits a highly structured surface which is characterized by gyri and sulci. A quantitative examination of the cortical surface can be performed by means of Fourier analysis. In the approach presented in this paper, Fourier descriptors are employed to investigate the spatial spectrum of cortical contours on cross-sections of the human brain. The contour of the brain is defined by the bounding curve in the complex plane and sampled at equidistant points. Fourier descriptors are obtained by a Fourier transformation of the sequence of complex values. This approach provides global frequency information on the whole contour. The proposed methods were validated using artificial data. The layer representing the cortical surface was modeled by a concentric sphere with a modulated circumferential oscillation. It was generated using two scaled basis functions of real spherical harmonics, the monopole and a second function that represents the spatial oscillation. For a given amplitude of the oscillation, the radius of the sphere was chosen such that the greatest extent of the inner layer was 63 mm, which corresponds to the radius of the cortical sphere of the commonly used four-layer conductivity model of the human head. Using the artificial data we showed, that the proposed approach is applicative for spatial frequency analysis of contours of the human brain. Furthermore, we investigated 10 MRI data sets of probands using this approach. The MR imaging was performed on an 1.5-T scanner (Magnetom Vision plus, Siemens AG). The cortical surfaces were segmented using the FreeSurfer software. For both hemispheres of the human brain, cortical contours of cross-sections in sagittal, coronal and transversal directions were analyzed. The estimated power spectral densities show for the sampled contours in all directions two distinct peaks. The first peak is located at wavelengths between 16 and 20 mm, the second peak between 8 to 12 mm. These values correspond to the sulcal depth and intersulcal distances that dominate in the human brain.

11:00 a.m. | M. Gratkowski (DE-Ilmenau), D. Lelic (DK-Aalborg)

Clustering of High-Dimensional EEG Data

Introduction: Source analysis of individual or grand mean evoked brain potentials (EPs) has difficulties studying group differences as few outliers can blur the outcome to a major degree, and the precise time or frequency of the waveforms is not taken into consideration. Recently, we have shown that the accuracy of inverse solutions can be significantly im-

proved by decomposing the EP data into components (usually termed atoms) well defined in time/frequency/space with Multichannel Matching Pursuit (MMP) prior to inverse modelling. We hypothesized that clustering on MMP atoms according to their time-frequency and dipole location would provide a much more reliable tool for studying differences and similarities between groups. Methods: The EPs were decomposed into a number of components well defined in time and frequency using MMP. Inverse modelling was applied to the components and sources were clustered. First, the procedure was tested on simulated EPs in ten phantom subjects, having seven different brain sources. The method was further validated on median nerve somatosensory EP data in ten healthy volunteers, where clusters representing the region around primary somatosensory cortex (SI) were studied. The method was compared to traditional grand mean peak-by-peak source localization and source localization on MMP decomposed grand mean of the same data. Results: For the simulated data, the clustering algorithm gave seven clusters with ten sources each and these sources were localized in correct brain areas. For the empirical data, the three main clusters represented the N20 SI component, background SI activity, and activity peaking frontally to SI around 30ms. For both datasets, the clustering method gave more reliable results than source localization on grand mean and MMP decomposed grand mean. Conclusion: This method proved to be an efficient way to group similar brain activity and thus study brain activation sequence to sensory stimulations.

11:20 a.m. | D. Strohmeier, A. Halbleib, M. Gratkowski, J. Haueisen (DE-Ilmenau)

The Epsilon-Skew-Normal dictionary: A new dictionary for Matching Pursuit based signal decomposition

In the last decade, different extensions to the well-established Matching Pursuit (MP) algorithm have been presented. These techniques, e.g. Multichannel Matching Pursuit (MMP) or Topographic Matching Pursuit (TMP), have been used for the analysis of biomedical recordings such as electroencephalography (EEG) and magnetoencephalography (MEG). Typical analysis schemes involve denoising, artifact reduction as well as component and topographic analysis in the time or time-frequency domain. Moreover, new applications in the field of biosignal source localization have been published. MP techniques are used to decompose single- and multichannel signals into spatio-temporal components (atoms). These atoms are taken iteratively from a highly redundant set (dictionary). Due to the optimal time-frequency characteristics, Gabor dictionaries are commonly applied. However, symmetric Gabor atoms fail at approximating asymmetric oscillatory components. Thus, we present the Epsilon-Skew-Normal (ESN) dictionary built from of symmetric as well as asymmetric oscillatory components. The ESN dictionary can be considered as an extension of the Gabor dictionary and is applicable to both, single- and multichannel recordings. Due to the similarity to the standard Gabor dictionary, existing MP algorithms can be easily adapted. We compare both dictionaries based on the decomposition of simulated as well as real EEG data and conclude that the Epsilon-Skew-Normal dictionary causes smaller decomposition errors.

11:40 a.m. | P. Fiedler, J. Haueisen (DE-Ilmenau)

Novel dry biosignal electrodes based on TiN: Influence of electrode number and arrangement on contact impedance and signal quality in EEG measurements

In order to use conventional biosignal electrodes for Electroencephalography (EEG) it is necessary to fulfill a set of requirements, including time consuming and complex preparation of the skin of a subject. This limits applicability in clinical routine, medical research and possible future applications. For this reason a new class of electrodes is being investigated, eliminating the need for electrolyte gels or pastes and thus being called "dry" electrodes. The concept of these novel electrodes results in the need for a stable and reliable contact with the subject's skin. In order to develop an electrode shape with large contact surface for low electrode-skin impedance while also ensuring a sufficient hair layer penetration, several studies were performed by the authors. In this paper a distinct titanium electrode substrate shape for titanium nitride (TiN) coated electrodes was analyzed regarding influences of the number of interconnected electrodes (called "pins") on electrode-skin impedance and the quality of the acquired EEG biosignal. As a result, 10 interconnected TiN pins had the lowest impedance values of 14 to 55 k Ω (depending on signal frequency) in comparison to 2 to 44 k Ω using conventional Silver/Silver-Chloride (Ag/AgCl) electrodes. Also the mean average deviation (MAD) of two parallel EEG recordings was calculated. The lowest MADs of 2.0 to 2.3 μ V were determined using three interconnected TiN pins. The MADs of 2.1 to 2.5 μ V using a second set of Ag/AgCl electrodes leads to the conclusion that most of the error was related to the measurement method, especially spatial distance of the compared electrodes. This first step in optimization of electrode arrangement showed very promising results and therefore demonstrates the potential of TiN-based electrodes for EEG acquisition.

12:00 noon | S. Klee, D. Link, P. Bessler, J. Haueisen (DE-Ilmenau)

Characterization and application of an optoelectrophysiological color stimulator

Introduction: Electrophysiological tests and appropriate stimulators are necessary for objective examination of the visual pathways. Therefore diverse stimuli were imaged on the retina and responses of the visual system were measured using electroencephalography and visual evoked potentials. The silent substitution technique is suitable for a selective chromatic stimulation of the short-, medium-, and long-wavelength-sensitive cones (S-, M-, and L-cones). We present the characterization and application of a combined optical imaging and functional stimulating technique for fundus-controlled optoelectrophysiological silent substitution investigations. Methods: We connected a digital color liquid crystal on silicon projector and an electron-multiplying charge-coupled imager to a fundus camera and used a light emitting diode for illumination. Characterizations of the optical and electro-optical components of the stimulator were performed using temporal and spatial modulation transfer functions. Two silent substitution flash sequences were presented to modulate selective activity in the S-cone and the LM-cone pathway. Simultaneously, the visual evoked potentials of six healthy males were recorded and analyzed. Results: The temporal and spatial characterization revealed a maximal contrast loss of 7% for the highest stimulation frequency (30 Hz) and maximum cut-off spatial frequencies of about 120 cycles/degree. For both silent substitution stimulations, we obtained a typical N1-P1 complex in the curve

shapes of the S-cone response and the LM-cone response. The latencies after LM-cone stimulation were markedly smaller than that after S-cone stimulation. All volunteers in the study showed higher peak-to-peak amplitudes in the LM-cone responses than in the S-cone responses. Based on the characteristics of all parameters, the ability to produce stimuli to access both the S-cone and the LM-cone pathway could be confirmed. Conclusion: We demonstrated a fundus-controlled optoelectrophysiological stimulation of the human retina using silent substitution technique. The new setup simultaneously provides retinal imaging and electrophysiological investigation of the patient's fundus. The functional integrity of different retinal areas can be examined under direct fundus control.

12:20 p.m. | P. Bessler, S. Klee, J. Hauelsen (DE-Ilmenau)

Selective color channel stimulation for objective detection of glaucoma

Introduction: Glaucoma is one of the most common causes of blindness. The aim of the study was the objective examination of glaucoma patients, using selective color channel stimulation based on the silent substitution technique and the classification of the recorded visual evoked potentials of glaucoma patients and healthy subjects. Methods: Visual evoked potentials were recorded for 29 glaucoma patients, 6 severe glaucoma patients and 31 age-matched healthy subjects. On the basis of silent substitution stimulation, cone-specific responses were obtained for short-(S), medium-(M), and long-(L) wavelength-sensitive cones. Stimulation was presented using a 30" liquid crystal display. The cone isolation was tested by an adaption and bleaching experiment. The electroencephalogram was recorded (sample rate 512 Hz) with two electrodes (Oz vs. Fz) simultaneously to the stimulation, using an electrode cap and Ag/AgCl ring electrodes. Results: We found variations in the curve shapes of the stimulated color channels. Statistical analysis revealed significant ($p < 0.05$) differences between the selective stimulated color channels. Furthermore significant differences were observed in some parameters between moderate glaucoma patients and healthy subjects. Distinct changes in the S-cone response profiles were observed in patients with severe glaucoma damage compared with that of a healthy subject following selective S-cone stimulation. Severe glaucoma damage is manifested in the S-cone response for 9 of the 10 eyes. A change in the S-cone response with disease severity can be shown in the analysis of the grand averages. Conclusion: The applied stimulation methods offered advantages in terms of objectivity and flexibility of selective color channel stimulation. We were able to objectively detect glaucoma and its severity using the silent substitution technique. Differences between the color channels of the visual pathways are visible. Therefore, the disease can be assessed by objective electrophysiological testing.

12:40 p.m. – 1:30 p.m. Lunch break

C4 Model-Based Design of Embedded Systems

Time: Wednesday, 15.09.2010

Location: Humboldt-Building, Lecture Room 129

Chairman: A. Zimmermann (DE-Ilmenau)

9:00 a.m.	St. Bosse (DE-Bremen)
<p>Hardware Synthesis of Complex System-on-Chip-Designs for Embedded Systems Using a Behavioural Programming and Multi-Process Model</p> <p>Embedded Systems used for control, for example in Cyber-Physical-Systems (CPS), perform the monitoring and control of complex physical processes using applications running on dedicated execution platforms in a resource-constrained manner. Traditionally program-controlled multi-processor architectures are used to provide the execution platform. There are two different ways to model and implement System-on-Chip-Designs (SoC) used in those embedded systems: using 1. a structural and/or 2. a behavioural level. The structural level decomposes a SoC into independent submodules - processor cores, memories and peripherals - interacting with each other using centralized or distributed networks and communication protocols. The behavioural level usually describes the behaviour of the full design interacting with the environment, generally a more sophisticated modelling level. In the context of CPS these are mainly reactive systems with dominant and complex control paths. The major contribution to concurrency appears on control path level. A new SoC-design methodology is presented using the behavioural hardware compiler ConPro providing an imperative programming model based on concurrent communicating sequential processes (CSP) with an extensive set of interprocess-communication primitives. The programming language and the compiler-based synthesis process enables the design of constrained power- and resource-aware embedded systems with pure Register-Transfer-Logic efficiently mapped to FPGA and ASIC technologies. Concurrency is modelled explicitly on control- and data path. Additionally, concurrency on data path level can be explored and optimized automatically by different schedulers. The CSP programming model can be synthesized to different other levels, not only used for hardware circuit synthesis: software models (C, ML), intermediate mCode, RTL state level, and finally VHDL. The C and ML output enables a common source for both hardware and software implementation with identical functional behaviour. An extended case study of a communication protocol used in high-density sensor-actuator-networks should demonstrate the design of a SoC for a robot actuator. The communication protocol is suited for high-density intra- and interchip networks.</p>	
9:20 a.m.	A. Osadchuk , W. Fengler (DE-Ilmenau)
<p>Survey of Network-on-Chip Research and Modelling Approaches</p> <p>The evolution of integrated circuit technology made possible a realization of so-called Multiprocessor System on Chip (MPSoC), where multiple heterogeneous processor cores are integrated on a single chip. As communication infrastructure MPSoC design uses the on-chip networks that have been proposed for System-on-Chip(SoC) integration. The main topic of this paper is to give a research survey over the last years in the field of networks-on-chip (NoC). This paper considers basic guidelines and advantages of NoC research. Some of prototyped NoCs will be presented here. As the subset of SoC, NoC are an integral part of SoC design and like in every design flow the modeling and simulation are important. It is necessary to model a behavior and to realize virtual prototypes of such systems to evaluate</p>	

the advantages of their technological implementation. However, NoC modeling is still an open research area. Several modeling techniques that are used in NoC design will also be presented and compared in this paper. We make this survey in order to develop an optimal modeling technique for future work.

9:40 a.m. | B. Däne (DE-Ilmenau)

Designing an Application for Field Programmable Gate Arrays – A Case Study

Field Programmable Gate Arrays (FPGA) are widely used for implementing various functions that previously would have been realized by software. For integration into complex model based design processes it is desirable to derive FPGA designs from high level models such as Matlab/Simulink models. For this purpose manufacturers provide tool support, but some difficulties remain to the user. The paper presents a case study that deals with such a design process while preparing a multiprocessor communication system using multiple FPGA. 2. PROJECT DETAILS Goal of the project that provides the basis for this case study is a decentralized communication system for a multiprocessor system consisting of Digital Signal Processors (DSP). This communication system should provide high throughput while maintaining low software overhead and low pin count. So a fast serial communication protocol is implemented into FPGA (one per processor node), completed by telegram buffers and interfaces to processor bus. Communication topology is a ring. 3. MODELING, CASE STUDY AND RESULTS High level modeling with Matlab/Simulink is used to develop telegram formats, error correction and other aspects of the communication protocol, as well as interfacing of FPGA to DSP. By adding behavioral models of DSP (i.e. bus cycles and test sequences) and error models for the serial lines the protocol is validated and analyzed for effectiveness within the modeling tool. Transformation into actual FPGA design is done by combining tools that are available commercially, and the result is checked against the results that derived from modeling. This process exposes some difficulties that must be addressed when integrating it into more complex design processes. This work partly has been supported by Deutsche Forschungsgemeinschaft (DFG). Matlab and Simulink are trademarks of The MathWorks, Inc.

10:00 a.m. | A. Pacholik, W. Fengler, T. Simon (DE-Ilmenau)

Case Study: Verification of an Embedded Operating System

Verification of complex distributed systems is a challenging task. There are a number of approaches, based on the correctness by design concept, involving code generation. However such approaches are not always feasible. On the other side embedded systems incorporate distributed multitasking systems, are hard to be verified by code analysis alone. In our approach we combine automated code level analysis with high level modeling of selected hardware mechanisms. The fitness of the approach is demonstrated by checking a number of critical properties in a custom real time operating system for a high performance 32-Bit digital signal processor.

10:20 – 10:40 a.m. **Coffee break**

12:00 noon – 1:00 p.m. **Lunch**

End of Lecture Session

Conference Programme

Scientific guided tours

**15.09.2010,
1:00 - 2:00 p.m.
(each tour starts
at the same time)**

**Meeting place:
Entrance to the
Humboldt Building**

Admission

All lecturers and participants are kindly invited to take part in the guided tours of research centres of the Ilmenau University of Technology.

The following tours will be held:

- * Competence Centre Virtual Reality
- * Centre for Micro- and Nanotechnologies (ZMN)
- * Institute for Automation and Systems Engineering

5 EUR for each guided tour

Conference Programme

Excursion and Banquet

15.09.2010, 2:30 p.m.	Coaches depart from the Mensa (Refectory) for the excursion to Erfurt, Capital of Thuringia
3:30 – 4:00 p.m.	Organ concert (at least 60 participants)
4:00 p.m.	The German- and English-speaking tourist guides will accompany you during the historic tour through Erfurt Guided city-tour where you will visit e.g. <ul style="list-style-type: none">- The Cathedral and St. Severi Church- The historic store "Waidspeicher"- The Building "Zum Sonneborn"- The "Fischmarkt"- The inn "Zum Alten Schwan"- The famous bridge "Krämerbrücke"- The Ägidien Church and- The Wenigemarkt
Information:	Further information about Erfurt: www.erfurt.de
Around 6:00 p.m.	Departure to Ilmenau
7:30 p.m.	Banquet in the Hotel „Tanne“ Ilmenau, Enjoy Thuringia's cuisine in an informal atmosphere www.hotel-tanne-thueringen.de
Admission	59,50 EUR (The Price includes 50,00 EUR net and 19% VAT (9,50 EUR))

Subject to alteration.

B2 Inverse Problems and Biosignal Processing 2

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: P. Husar (DE-Ilmenau)

9:00 a.m.	M. Weis, D. Jannek, T. Guenther, P. Husar, M. Haardt, F. Roemer (DE-Ilmenau)
<p>Space-Time-Frequency Component Analysis of Visual Evoked Potentials based on the PARAFAC2 Model</p> <p>In this contribution we focus on analyzing measured electroencephalographic (EEG) data to identify the components of neural activity. The component analysis of EEG data is widely used in neuroscience. In the functional diagnosis of evoked potentials, the EEG component analysis is of high relevance for an objective electrophysiological assessment. Moreover, these techniques can be used to detect and localize epileptic seizure onset zones on the scalp as well as projections of cognitive processing like speech or auditory handling. Different component analysis techniques have been applied over the last years, e.g., independent component analysis (ICA), and the singular value decomposition (SVD). However, these methods cannot exploit the multi-dimensional (space-time-frequency) structure of the EEG data. Moreover, to obtain matrix decompositions like the SVD or the ICA, artificial assumptions like orthogonality or independence have to be imposed. For these reasons, tensor decompositions are a more promising approach to handle EEG signals. Especially the well known parallel factor (PARAFAC) analysis is widely used in recent literature, because it is essentially unique under mild conditions without any artificial constraints. For the efficient multi-way component analysis of EEG data it is necessary to resolve the temporal evolution as well as the frequency content of the EEG recordings. In order to achieve this, a time-frequency analysis (TFA) is applied to each channel. After the TFA, the EEG signals vary over time, frequency, and space (channels). The common approaches for the space-time-frequency component analysis of EEG data to date are based on the PARAFAC model. However, this model is not able to resolve EEG components which appear time-shifted over the different channels. In this contribution we introduce the PARAFAC2 decomposition for the space-time-frequency analysis of EEG data. Thereby, we show that the PARAFAC2 model supports time-shifted component signals. The validity of the model is demonstrated on measured visual-evoked potentials (VEP). Furthermore, we show how the PARAFAC2 model can be adopted in order to track the different EEG components over time, which provides new insights into the temporal evolution of EEG components.</p>	
9:20 a.m.	T. Guenther, M. Weis, D. Jannek, P. Husar (DE-Ilmenau), A. Wilms (DE-Erfurt)
<p>Polygraphic representation of anxiety disorder – a case study</p> <p>Anxiety disorder is a highly prevalent psychological disorder which affects about 15% of the population in developed countries. The psychological diagnosis and therapy of anxiety disorder are well studied. However, many therapy sessions are required and long waiting periods prevail. The main goal of the PsychoPort project is the development of a mobile device which measures and processes biomedical signals and triggers psychological</p>	

interventions in order to support the psychological therapy. In this contribution we focus on the investigation of differences in biosignal measurements during a phobic reaction and a relaxed emotional state as well as the interaction of multiple biomedical signals prior to the state of pathologic anxiety. For such information is necessary to reliably detect a phobic reaction. In this paper an exemplary case of anxiety disorder is examined. Four different biomedical signals are monitored, namely the electrocardiogram (ECG), the skin resistance level (SRL), four electromyogram (EMG) leads at regions with high tension potential and three respiration belts. The measuring session is divided into three stages. First, the patient is exposed to an invasive video depicting a situation that relates to their anxiety disorder. Second, another video is presented, which depicts a positive ambiance according to the patient's liking. At last progressive muscle relaxation is used to provide a state of high relaxation. The obtained signals and their interactions are analyzed statistically, in the time-frequency domain and by extraction of characteristic parameters used in state-of-the-art psychophysiological research. The resulting parameters of the three measuring stages are compared with respect to the patient's subjective evaluation of the perceived level of fear. As the presented case study is work in progress, detailed results will be presented in the conference paper.

9:40 a.m. | D. Laqua, S. Ley, T. Just, P. Husar (DE-Ilmenau)

Methodical and experimental analysis of biological tissue for low power in vivo RF transmission

Periodical recording of vital parameters is an important fact in clinical routine. Especially in high risk groups such investigations are necessary. For example the measurement of the intraocular pressure can be useful for early diagnostics of the glaucoma. Thereby a short measurement interval is desirable. A wireless intra corporeal sensor is the best solution for patients. By using a wireless radio frequency (RF) transmitter the need of a percutaneous connection isn't necessary. Thereby the risk of an infection is reduced. For the design of such a transmitter the dielectrically characterization of representative biological tissue is required. For this two methods are presented, the transmission line and the coaxial probe method. Furthermore the concept of an intra corporal transmitter is presented and by involving the dielectric parameters a miniaturized RF transmitter was designed. The build prototype was used to measure the transmission out of different phantoms, with equivalent dielectric properties like human tissue.

10:00 a.m. | D. Lazutkin, D. Laqua, P. Husar (DE-Ilmenau)

Modeling of Low-Field Magnetic Stimulation of the Human Brain

The World Health Organization reports depression to become the second leading cause of disability worldwide after heart disease by 2020. The most popular forms of depression treatment nowadays are antidepressant medication and recently adopted transcranial magnetic stimulation (TMS) of human brain. To overcome their disadvantages we are investigating an application of low-field magnetic stimulation (LFMS) to depression treatment. The work is based on the proven influence of low-intensity electromagnetic fields on biological cells, but takes into an account disputes regarding effects of an

exposure to LFMS for complex systems. As instruments and methods are known for TMS, the 3D electromagnetic model of TMS was developed and debugged before the modeling of LFMS was credited as legitimate. The TMS model employed a standard figure-of-eight coil placed above the human head. The LFMS model employed 8 small coils disposed on each side of the head around the points F3 and F4 according to the international 10-20 system. The head was modeled so that various tissues were represented by homogeneous concentric spheres of different size. An initial approach towards the development of a realistic human head model was made. Radiological data of a 66-year-old Caucasian male from the Visible Human Project were used for surface reconstruction. Obtained LFMS model shown that using a sinusoidal current with a peak value of 1 A at the frequency of 1 kHz the coils were capable of generating peak magnetic field of 66 mT within the core what corresponded to the electric field of 41 mV/m inside the head. A current density in the order of 0.1 mA/m^2 was induced up to 10 mm deep into the brain, when its conductivity was 0.08 S/m. Knowing the order of electric and magnetic fields in LFMS model, it is possible to initiate drafting of a technical specification for the stimulation device. The main challenge for the future research is to find the best trade-off between the realistic head model quality and solution time. As well it is planned to conduct a validation of performed modeling against the field measurements within a human head phantom.

10:20 – 10:40 Coffee break

10:40 a.m. | A. Tanelo, A. Gusiwki (BY-Minsk)

Computer image analysis for neurosurgery rehabilitation

For the treatment and follow-up care of patients with a cerebral blood flow disorder, encephalograms (EEG) are widely used, and to analyze its results, high-qualified doctors should be available. Application of remote access via Internet or radio relay links allows one to analyze EEG results in a specialized medical institution with highly skilled doctors available. For the distance access we use a system like vector network analyzer which traditionally based on the physical transfer of MI (measuring instruments) and the number of calibrating facilities to the metrological service (MS). Realization of the "remote calibration" using Internet as means of data transmission has been developed as the solution of the problems related to MI transportation, environment contamination, time expenditure and high cost of the existing calibration systems. The service system of EEG calibration via the Internet is based on the TCP-IP protocol for providing a two-way communication between a server and EEG of the consumer. The data flow between the server and the client includes the measured data and control commands via the vehicle channel for EEG. EEG software contains the functions enabling to save and display the data files both on the screen and on the paper, to stop or restart the process of measurement. The data are stored on the server, and can be seen on the local computer of the client for using in documents or in the certificates on calibration. The clinical presentation after the surgery depends on lesion focus localization and is revealed by various kinds of neural disorders, including motor, sensitive, referred abnormalities, thus causing the necessity to apply physical factors. As the guiding syndrome for this category of patients is the vascular one, it should be expedient to include into the rehabilitation program physical factors with apparent vasoactive action – combined effect of infrared and millimeter waves' range, and also magnetic fields.

11:00 a.m.	R. Haase, V. Hietschold, M. Andreef, H.-J. Böhme, N. Abolmaali (DE-Dresden)
<p>A new segmentation algorithm for low contrast Positron Emission Tomography based on Ant Colony Optimization</p> <p>Aim: In modern oncology, non-invasive imaging of aspects of tumor biology has a growing importance. One issue is tumor hypoxia imaging, for example with positron emission tomography (PET) using the tracer 18F-fluoromisonidazole (FMISO). But FMISO-PET datasets usually show a low target to background contrast along with a low signal to noise ratio. So the exact delineation of the hypoxic tumor subvolume is typically done manually and challenging, even for experienced oncologists. For this purpose we propose a fully automatic segmentation algorithm. Methods: Our new approach is based on the ant colony optimization (ACO) meta-heuristic introduced by Dorigo (1999), combined with thresholding the pheromone field, which is generated by virtual ants exploring the PET dataset. To evaluate the new approach, it has been applied on simulated low contrast phantom datasets and experimental phantom measurements from a Biograph16 PET/CT scanner (Siemens). In the final paper, we will present experimental results regarding reproducibility, versatility and applicability of the approach under various conditions. Results / Conclusion: First results indicate that the approach can be successfully applied to segment low contrasted PET images with a homogeneous background and homogeneous target objects. The experimental phantom datasets, where the activity inside the target objects is not homogeneously distributed, can be segmented by the new approach, too. References: M. Dorigo and G. Di Caro, The Ant Colony Optimization Meta-Heuristic. In D. Corne, M. Dorigo and F. Glover, editors, New Ideas in Optimization, McGraw-Hill, 11-32, 1999.</p>	
11:20 a.m.	S. Buhl, B. Neumann, S. Burkhard, E. Eisenbarth (DE-Iserlohn)
<p>Segmentation of cytological steined cell areas and generation of cell boundaries in complex shaded cell clusters</p> <p>The application of implants for humans have increases very rapidly since the advent of new materials. This makes a significant contribution for the improvement of life quality. The supplier of implants has to guarantee that the inserted implants are well accepted by the adjacent tissue. That's why a lot of extended tests of biocompatibility of the materials in use have to be carried out. The cell analysis with image processing includes the kind of shape expansion, the distribution and length of cell extensions, the density of population and the cell-cell-contacts. The demand of the biologists to use only cytological staining is a great challenge for image processing because the different cell areas vary only little by contrast. Our cell cultures show a lot of shape varieties. For that reason it is very difficult to find the correct cell boundaries of the individual cells within the cell clusters. Our segmentation of different cell areas (cell core, ectoplasm, endoplasm) are based on backprojection algorithm or by use of artificial neuronal network. The use of the methods for cell separation recommended in literature is not very successful with respect to our cell types. We represent a new method that is more successful with regard to cytological demands. Our algorithm connects the different cell cores with lines which lie within the region of a cell cluster. Along these lines the algorithm searches for that points where the cell separation is most plausible under cytological aspects.</p>	
12:00 noon – 1:30 p.m. Lunch	

B2 Inverse Problems and Biosignal Processing 2

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: P. Husar (DE-Ilmenau)

1:30 p.m.	M. Golz, D. Sommer, T. Schnupp, Ch. Heinze (DE-Schmalkalden)
Technological Measures for Alertness Management An introduction is given to the risk of fatigue during sustained operations and an overview is presented on different types of countermeasures to tackle this problem. Three different research activities in this area are considered with more attention, fatigue monitoring, fatigue testing, and modelling and simulation of the sleep-wake cycle. The first two approaches are at the short-term level, whereas the latter is operating in order to get long-term predictions. Afterwards, our special concern is directed to extreme central fatigue and microsleep events. Electroencephalography (EEG) was utilized to assess the underlying neurodynamic processes. During several test runs in the driving simulator a relatively large amount of biosignal and video material was recorded. Adaptive signal processing and pattern recognition techniques were applied. The resulting detection accuracy was validated by different random and fixed cross-validation schemes. This led to estimations of the inter- as well as intra-individual variability of the detection accuracy. It will be shown, that this variability is not mainly caused by methodology, like e.g. due to random initialization, or random computational order. Therefore, it is concluded that the EEG and possibly also the underlying processes offer a large inter-individual variability. This is indirectly confirmed by observations of behaviour and by investigations of microsleep density (MSD) across subjects. MSD was recently introduced by the authors as a measure of extreme fatigue and is a result of consecutive classification of a trained classifier in the recall mode to the total data set. MSD was estimated under the assumption that detectors adapted to selected doubtless examples of microsleep produce good estimations also for non-evident examples. Results show that MSD strongly correlates to other independent variables associated to fatigue, like e.g. the subjective self-rating of sleepiness, the standard deviation of the lateral position of the vehicle in lane, and to a simple measured variable of accident probability. Finally, several applications are highlighted and their properties are judged subjectively.	
1:50 p.m.	D. Sommer, T. Schnupp, M. Golz (DE-Schmalkalden), J. Krajewski (DE-Wuppertal)
The Pupillographic Sleepiness Test Analyzed by Computational Intelligence Methods Analyzed by Computational Intelligence Methods	
2:10 p.m.	T. Schnupp, C. Schenka (DE-Schnalkalden), J. Krajewski (DE-Wuppertal), M. Golz (DE-Schnalkalden)
Data Analysis of the Compensatory Tracking Task Using Computational Intelligence Introduction Several attempts had been made to assess vigilance by test procedures within short time. Short-term observations lead to increased uncertainty. On the other hand,	

methods of computational intelligence are known to deal with large variance and limited amount of data which prevents the application of parametric statistics. This contribution aims at improving vigilance estimation based on the compensatory tracking task (CTT) by the application and optimization of Support-Vector Machines (SVM). Experiments During the test duration of ten minutes subjects are instructed to maintain a minimum distance between a disk-shaped cursor and the annular target (screen-center). The cursor's motion is affected by forces unpredictable for the subject. Analysis of the visuomotoric performance presented here is restricted to cursor-target distances sampled at a rate of 12.75 Hz. Methods Extracted time-domain feature set utilized methods specialized for posturography. The extracted spectral-domain feature set utilized spectral densities estimated using Weighted Overlapped Segment Averaging (Welch's method) and subsequent averaging in equidistant spectral bands. Seven binary classification problems were defined using class "vigilant" and seven classes of different levels of "hypovigilance". Data was assigned to classes according to subject's time-since-sleep (TSS). Different classifiers were applied and compared in terms of lowest test set error rates using 25-fold delete-d validation. Results & Conclusions With rising TSS classification error rates reduce, indicating that the extracted features are sensitive to hypovigilance. The combination of SVM and spectral-domain features resulted in lowest error rates of 6.3 ± 10.6 %. Extended experiments need to prove that these results are replicable with a larger group of subjects.

2:30 p.m.	Ch. Walther, R. Baumgart-Schmitt, Ch. Menz, D. Trommer, M. Krautwald, K.-P. Sturm (DE-Schmalkalden), U. Jäger (DE-Steinbach-Hallenberg)
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Multi-Criteria Model-driven Feature Selection using Fuzzy Ruled Classification of Stages of Anaesthesia

The optimal feature selection to classify stages of anaesthesia by fuzzy rules should be identified. The one-channel frontal electroencephalogram (EEG) was measured on the forehead during operations and establishes the feature set for the classification task. No other vital data like heart rate or blood pressure is used. Data sets from 200 patients and operations were considered. Three different stages of anaesthesia are defined as light, normal and deep anaesthesia to estimate the optimisation. The Strength Pareto Evolutionary Algorithm (SPEA) was used to select the features used by the fuzzy rules. This algorithm was available in the advanced second version. The Receiver Operating Characteristic (ROC) is calculated based on the combination of features used to classify the stages of anaesthesia. The classification performance for each anaesthetic stage describes the true-positive (sensitivity) and the false-positive (specificity) recognition of the epochs of all EEG data sets. By using three different anaesthetic stages six different criteria are used to optimize the feature selection and the corresponding fuzzy rules. So a multi-criteria optimisation model is established. The analysis of the produced ROC-curves results into an optimal estimation of feature sets which can be used by the fuzzy rules to classify the stages anaesthesia. To reduce the dimensionality the parameters of the fuzzy sets and the general structures of the rules are invariable. The selection of the fuzzy sets is only optimized which corresponds to the selection of the features to classify the anaesthesia stages.

2:50 – 3:10 p.m. Coffee break	
3:10 p.m.	D. Trommer, M. Krautwald, R. Baumgart-Schmitt, Ch. Menz, Ch. Walther (DE-Schmalkalden)
<p>The recursive ICA, a new recursive approach for separating one signal source from dominant noise</p> <p>In this approach a signal extraction algorithm for bioelectrical signals measured by a sensor array under low signal noise ratio will be conducted. As an example the algorithm can be used for signal pre-processing before a classification algorithm should work. A well known approach for blind source separation of a linear mixture of signals, which will be measured by a sensor array, is the Independent Component Analysis [ICA]. In our case only one source is relevant. We propose that the ICA can separate a single source from noise and artefacts. Therefore the quality of a downstream classification can be improved. Mostly by using several derivatives of ICA, the processing time depends on the dimensions of the mixture space and often no information about previous computations can be used to improve accuracy or processing time. In this new approach we have implemented a fixed-point ICA algorithm in a recursive way and extend it by a feedback to its results computed before. We are using an own window-function for splitting the complete dataset into several parts. Also we propose that the algorithm can be used for signal pre-processing in real time classification systems. For this purpose the input of the algorithm should be a dataset with the length of such a window. Thereby the initial value of the algorithm will be adapted and the result of the calculated ICA-window of the next dataset will separate the same source-signal as it has been done by the calculation before. The variation between the current and the previous windowed dataset will be calculated too. In our approach with the case of nearly permanent values of the linear mixture between the different sources the ICA has to run only once. If the variation between two datasets becomes too high, the mixed collected data will be corrected by the use of the former result of the ICA. By using our new approach the processing speed can be improved, because it is mostly depending on the variation between two datasets. This approach was validated with synthetic and real data.</p>	
3:30 p.m.	M. Krautwald, D. Trommer, R. Baumgart-Schmitt, Ch. Walther, Ch. Menz (DE-Schmalkalden)
<p>Parameter optimization for Support Vector Machines by using a multicriteria genetic algorithm for classification of sleep-stages</p> <p>For Support Vector Machines (SVM), like all methods of classification, the choosing parameters determine the quality of classification. Searching these parameters is an optimization problem. This can be solved with different methods. One approach for solving an optimization problem is the genetic algorithm, which has his background in the biological evolution. In this paper a multicriteria genetic algorithm should introduced. It base on the Non-dominated Sorting Genetic Algorithm (NSGA) II, published 2000 by Deb. The algorithm has been adapted for parameter optimization of SVM to classify sleep-stages. Therefore it includes all values of the confusion matrix for searching fronts. We separate sleep in maximum eight stages. That means the confusion matrix has up to 64 elements which are used as criteria. Further criteria are the total right classified data in percent, the</p>	

diagonal and the geometrical mean of the confusion matrix and the accuracy of the poorest class. That means the pareto set is embedded in a up to 68-dimensional space. Each criterion to sort every result in a front can be weighted by the user to afford an optimal adaption on the given problem. Additionally to the original genetic methods the introduced algorithm generates every population some completely new individuals in a variable percentage rate. With it a single-edge development should be avoided. The sleep classification based on electroencephalogram (EEG)-data which were collected with a frontal one-channel electrode. Datasets of different test persons were used. How the genetic algorithm influence the classification quality will be demonstrated in this paper. Different experiments with the real sleep data, but also with synthetic data, show that classification quality of SVM increases by using the adapted genetic algorithm for parameter optimization.

3:50 p.m.	Ch. Heinze (DE-Schmalkalden), U. Trutschel (USA-Stoneham), D. Sommer, M. Golz (DE-Schmalkalden)
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Recurrence plots and their application to long-term heart rate recordings for the analysis of circadian rhythmicity

The ECG, which requires merely the application of electrodes combined with a mobile recording device, provides an assessment of circadian rhythmicity. This is limited due to many influences, among them are the complex regulation by the autonomic nervous system and of the suprachiasmatic nucleus. Therefore, the heart rate (HR) time series is highly variable and irregular. It was investigated if methods of nonlinear signal analysis can reveal circadian characteristics of long-term HR signals. Analysis was based on ECG of three young adults who participated in an unsupervised 50-hour data recording protocol during their normal daily routine. In addition, subjectively rated sleepiness and motoric activity (via wrist actometry) were recorded simultaneously. State space trajectories of HR series were reconstructed by time delay embedding. Recurrence plots (RP) provide a 2-dimensional representation of all times when a trajectory revisits roughly the same area in state space. The interpretation of large- and small-scale patterns within RP reveals different qualities on the evolving trajectory, such as determinism, periodicity, fractal dimension, or intermittency; recurrence quantification analysis (RQA) quantifies number and duration of the different RP properties. A sliding window (width 60 minutes, step size 1 minute) was applied to all HR series; for each window, RPs (ca. 3000 per subject) were constructed and quantitative features were extracted. The occurrence of similar events, like peaks and troughs of sleepiness, peaks of physical activity, transitions from sleep to wake or vice versa, resulted in similar RP patterns. Extracted features from more traditional methods of nonlinear HR analysis, particularly Poincaré plots, contained stronger spectral components around circadian period length than RQA features. On the other hand, RQA features revealed a strong sensitivity to sleep initiation or to the wake-up time. In conclusion, RP features are sensitive to circadian variations and therefore provide means to adapt the free parameters of sleep-wake models for each individual. This will improve the technological basis of fatigue risk management.

End of Lecture Session

B2 Inverse Problems and Biosignal Processing 2

Time: Thursday, 16.09.2010, 4:10 p.m.

Location: Humboldt-Building, Room 211 / Foyer

Poster Session:
Chairman: P. Husar (DE-Ilmenau)
H. Welp, V. Jaedicke, Ch. Kasseck, N. C. Gerhardt, M. R. Hofmann (DE-Bochum)
Spectral pattern classification in optical coherence tomography In recent research on optical coherency tomography (OCT) several approaches are pursued to retrieve not only morphological information from the analysis of the backscattered light but also depth dependent spectroscopic information. Since many substances in life science and material science have characteristically shaped spectral extinctions in principle this allows depth dependent substance identification. We present a concept using a pattern recognition algorithm to perform depth resolved substance identification in non-scattering samples based on spectral features. A proof of principle is given by frequency domain OCT (FD-OCT) measurements of a multilayer absorbing sample. The reconstruction of depth dependent spectra is done by a windowed Fourier transform of individual peaks in the complex FD-OCT depth profile. Based on the reconstructed spectra transmission functions are calculated iteratively for certain depth regions. Then the transmission functions are classified according to the known transmission profiles of expected substances using a pattern recognition algorithm. For a multilayer sample with four different absorbers our concept yields an overall sensitivity of 80% and an overall specificity of 96%. These results were achieved without performing calibration measurements in order to eliminate systematic errors. Thus high performance, fault tolerant substance identification based on spectral changes caused by absorption is feasible. The fault tolerance of our concept is especially important for real applications where calibration measurements are not applicable. Our proof of principle outlines the potential of spectral feature based substance identification in non scattering samples e.g. for material sciences. With further improvements this concept can be extended to strongly scattering media like biological tissue.
A.Sh. Avshalumov, G.F. Filaretov, V.B. Markovsky, E.N. Sinitsyna
The Method of Principal Components as an Instrument for Analysis of Oral Glucose Tolerance Test Dates It is proposed to use the method of principal components (MPC) as an instrument for date's analysis of oral glucose tolerance test (OGTT), which plays very important role in diabetic diagnoses. This test is realized by the taking fasting of dry 75 g glucose dissolved in 250 ml of water, and measuring concentrations of immunoreactive insulin (IRI), glucose and C-peptide in blood plasma at the initial (zero) time and after 30, 60, 120 minutes after taking. Standard processing of test results is usually limited to fixing the initial and end levels of IRI, evaluation of various indexes (CARO, HOMA-IR, HAFFNER, etc.). This method does not allow to extract all useful information from measurements. As it was shown on the basis of sufficiently representative clinical material, using of the MPC for OGTT data processing is

very perspective. This is established, that: - basic information about the presence and level of hyperinsulinemia is contained in the first principal component F1; - F1 values for healthy patients and patients with signs of pathology are clearly separated; - there is a significant correlation values F1 and standard indexes; - dynamics of change in F1 values can clearly judge about the efficiency of therapeutic procedures. Stability of diagnostic results by using indicator F1 with increasing number of examined patients and correction of the estimated coefficients in formula for F1 are considered.

**C5 - First International Workshop on Evolution Support for
Model-Based Development and Testing (EMDT2010)**

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 202

Chairman: M. Riebisch (DE-Ilmenau)

9:00 a.m.	M. Riebisch, Qurat-ul-Ann Farooq, St. Bode, (DE-Ilmenau)
Welcome and Introduction	
9:05 a.m.	B.-H. Schlingloff (DE-Berlin)
Keynote: Model-Based Software Development – Perspectives and Challenges Model-based software development and testing has turned out to be the method of choice for safety-critical embedded systems. An abstract model reflects requirements and environmental conditions for the system. Such a model can be used in two ways - as a development model in a stepwise refinement process to derive the actual implementation, or as a testing model in order to derive test cases for some system under test. In this talk we discuss commonalities and differences between development models and testing models, discuss the formalization of requirements in models, and show how to automatically evaluate observations about a system with respect to a model. We illustrate our ideas with examples from aerospace, automation and medical devices. Finally, we discuss some recent trends and challenges in the area of model-based development and testing.	
9:50 a.m.	B. Güldali, M. Mlynarski (DE-Paderborn)
Invited Talk: Agility vs. Model-based Testing: A fair Play? "Agile manifesto" defines principles of a light-weight software development process for an improved customer satisfaction: adopting to changing requirements, frequently delivering working software in short cycles, and close collaboration of business people and developers. Automated testing plays an important role for assuring the quality of delivered software. Especially for the repeating activities of regression testing and integration testing, automated tools are indispensable for assuring short development cycles. "Model-based testing" is a widely accepted technique which extends the test execution of classical test automation by test design and test implementation. Thereby, logical and executable test cases are generated from formal test models. Thus, model-based testing can speed up the test automation in agile development processes. However, creating and maintaining the test models imply some challenges if model-based testing should be embedded into the agile development: How can we create test models efficiently? How can we assure the adoptability of test models? Can we use test models for communication with the business people? In this talk, we will discuss how model-based testing can support agile development without conflicting with the principles of agile manifesto.	
10:20 – 10:40 a.m. Coffee break	

10:40 a.m.	N. Kosindrdecha, J. Daengdej (TH-Bangkok)
<p>A Test Case Generation Technique and Process</p> <p>It has been proven that the software testing phase is one of the most critical and important phases in the software development life cycle. In general, the software testing phase takes around 40-70% of the effort, time, and cost. This area is well researched over a long period of time. Unfortunately, while many researchers have found methods of reducing time and cost during the testing process, there are still a number of important related issues that need to be researched. This paper introduces a new test case generation process with a requirement prioritization method to resolve the following research problems: (a) inefficient test case generation techniques with limited resources (b) lack of an ability to identify critical domain requirements in the test case generation process and (c) ignore a number of generated test cases. In brief, the contributions are to: (a) study a comprehensive set of test case generation techniques since 1990 (b) concentrate on the model-based generation technique (c) define a new process to generate test cases (d) provide a guide for the direction of future research.</p>	
11:00 a.m.	Chr. Kop, G. Fliedl, H. Mayr (AT-Klagenfurt)
<p>From Natural Language Requirements to a Conceptual Model</p> <p>In literature it is described in great detail how class diagrams and ER diagrams or UML class diagrams are derived from natural language sentences. It is normally assumed, that there is a direct correspondence between natural language elements (e.g. words) and conceptual model elements. We do not strictly follow this assumption because of the complexity of natural language with its ambiguities and ellipsis. Hence in this paper a stepwise generation of a conceptual schema out of natural language requirements sentences is proposed. According to the ideas of MDA we assume that automatic transformation steps from the source model (in our case natural language) to the target conceptual model (e.g., UML class diagram) make sense. In addition to that we suggest that the designer should play an important part during transformation. It is furthermore proposed to introduce an interlingua between the conceptual natural language and the UML class diagram.</p>	
11:20 a.m.	S. Roongruangsuwan, J. Daengdej (TH-Bangkok)
<p>Test Case Reduction Methods by Using CBR</p> <p>Statistics gathered in past research show that testing, analysis, and debugging costs usually consume over 50% of the costs associated with the development of large software systems [5]. Many techniques have been proposed that reduce time and cost, such as test prioritization, regression selection and test reduction methods. Although, there are many proposed techniques, there are outstanding research issues that motivated this study: (a) redundancy test cases are still remaining (b) a size of test cases is still too big and (c) existing reduction methods consume a great deal of time. This paper introduces a new process, called "3R-2S-3R-2R". Also, it proposes reduction methods using case-based</p>	

reasoning. In brief, the contributions are to: (a) study a comprehensive set of existing reduction methods (b) introduce a new concept of CBR for removing non-necessary test cases (c) define a new reduction process (d) propose and compare reduction methods and (e) guide future works.	
11:40 a.m.	M. Riebisch, Qurat-ul-Ann Farooq, St. Bode (DE-Ilmenau)
Introduction to the goals of the group discussion	
12:00 noon – 1:30 p.m. Lunch	

**C5 - First International Workshop on Evolution Support for
Model-Based Development and Testing (EMDT2010)**

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 202

Chairman: M. Riebisch (DE-Ilmenau)

1:30 p.m.	All participants
Group discussion part I	
2:50 – 3:10 p.m. Coffee break	
3:10 p.m.	All participants
Group discussion part II	
3:50 p.m.	All participants
Conclusion of the discussion, deliberation of further steps	
4:20 p.m. End of Lecture Session	

C6 Systems and Network Security Doctoral Workshop

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 204

Chairmen: W. Kühnhauser, G. Schäfer (DE-Ilmenau)

1:30 p.m.	A. Fischer, W. Kühnhauser (DE-Ilmenau)
<p>Causal Trusted Computing Bases</p> <p>Today's trusted computing base (TCB) designs are guided by seeking generality to support a wide variety of security policies. As such they are powerful general-purpose TCBs, and implementing them inevitably leads to complex implementations. Consequently, correctness, robustness and tamperproofness of a TCB's implementation are quite hard to verify. If a TCB is a set of functions required to enforce and protect a system's security policies, TCBs by definition only contain functions required by the system's security policies and thus provide minimal functionality. Applying this definition, however, poses the problem to exactly identify causal dependencies between security policies and TCB functions. In this idea paper we present a research concept that specifies causal dependencies between security policies and TCB functions and properties, aiming at reducing the size and complexity of a TCB's implementation. Our approach leads to a functionally scalable TCB design that allows for causal dependency analyses. As a result, we establish a promising breeding ground for analysing the correctness, robustness and tamperproofness of a TCB's implementation.</p>	
1:50 p.m.	F. Girlich, M. Rossberg, G. Schäfer, Th. Böhme, J. Schreyer (DE-Ilmenau)
<p>Scrubbing the Vivaldi network Coordinate System</p> <p>Over the last years network coordinate systems have gained much attention as they allow for an elegant estimation of distances between peer-to-peer endsystems. Most prominent representative of these approaches is Vivaldi, which is using a mass-spring-damper system to embed peers in a two-dimensional euclidean coordinate space with an additional height coordinate to model access delays to the core network. In unimpaired overlay networks this simple method leads to a good approximation of pairwise delays. Unfortunately, like most distributed algorithms, Vivaldi is likely to suffer from byzantine failures and several attack methods and countermeasures have been proposed. In this paper we present several novel issues and countermeasures, and in particular examine an attack method to exploit violations of the triangle inequality.</p>	

Secure Multi-hop Localization in Wireless Ad Hoc Networks

Wireless Ad Hoc Networks offer a wide variety of possible applications in the context of sensor networks ranging from environmental monitoring to intrusion detection and battlefield surveillance. An important service for these applications is the precise and accurate localization of the participants. Equipping each node with GPS is often considered an expensive and impractical approach. Thus the problem of localizing sensors using only a small fraction of anchor or beacon nodes, which are aware of their location, has gained much attention from researchers in the past decade. Many schemes assume cooperative behavior among the nodes to achieve localization. Since many applications require the deployment of nodes in an adversarial environment, the problem of providing secure and robust localization has led to a variety of mechanisms aiming at either preventing the attacker from disturbing the process of localization, detecting and repairing such intervention or using robust statistical methods like least median of squares to offer graceful degradation in the face of an attack. Yet most approaches require single-hop communication between nodes and anchors to conduct distance measurements using received signal strength indicator, time of arrival or time difference of arrival. In contrast, multi-hop schemes require only a small amount of anchor nodes for localization. Such mechanisms often provide a rough estimation by flooding the location of the anchor nodes into the network. Nodes receiving this information forward it to their neighbors while either incrementing a hop counter or summing up distance measurements along the path. With participants receiving the location and distance to at least three anchor nodes, they are able to estimate their own location. The nodes subsequently refine this estimate by iteratively exchanging locations and distance measurements with their direct neighbors. Despite their promising nature, not much effort has been made in the past to secure multi-hop localization schemes. This work identifies objectives to be fulfilled by multi-hop based mechanisms aiming to provide secure localization and analyzes strengths and possible weaknesses of existing approaches regarding these objectives.

2:30 p.m.	I. Muhammad, K. Panitzek, M. Mühlhäuser, Th. Strufe (DE-Darmstadt)
<p>First Thoughts on a Secure and Reliable Peer-To-Peer Service Platform</p> <p>Harnessing the P2P paradigm to provide a distributed service platform for the implementation of online social networks, IPTV, emergency first response systems, multi-player online games, or especially cloud computing platforms raises novel security challenges. Critical resources have to be allocated and shared in a decentralised manner in all these applications. P2P systems, though inherently robust to churn, generally are not resilient to adverse behaviour. Yet, it is paramount to guarantee fair use and especially to make them immune to internal as well as external adversaries. In this paper we outline our future research directions to ensure security and reliability of P2P service platforms, in dynamic as well as hostile environments. Our focus lies on the challenge to guarantee fair and reliable load balancing while keeping the services available and secure.</p>	
2:50 - 3:10 Coffee break	
3:10 p.m.	M. Trapp, G. Schäfer, M. Fischer (DE-Ilmenau)
<p>Heterogeneity in Peer-to-Peer Live-Streaming</p> <p>Application Layer Multicast (ALM) has become a popular form of content distribution, due to its inherent scalability properties and the overcoming of the client-server-bottleneck. Content is distributed from a source to a large number of peers by utilizing their resources for redistributing the stream to other peers. So, the system can grow independently from the source's upload bandwidth. Caused by an increasing availability of high-speed radio communication (eg. 3G or LTE), a large fraction of devices, taking part in future ALM systems, will be mobile and hence not as stable as stationary ones (eg. breakdown of the radio connection). These devices make use of various access technologies at once and will be highly heterogeneous in their available bandwidth. So, a vertical handover can have huge impact on a peer's ability to forward content. After analyzing current mobility protocols and finding no suitable approach, we developed an integrated approach to handle mobility and node heterogeneity within an ALM system that can preserve the operability of the system even in a worst-case scenario with high mobility load.</p>	

IPTV - The Case for Peer-to-Peer Live-Streaming

Internet Protocol Television (IPTV) is becoming more and more popular and will burden future networks heavily with traffic, especially if deployed with a classic client-server-like approach. Besides, it does not scale. Application Layer Multicast (ALM) and its Peer-to-Peer (P2P)-like content distribution is a promising technology to overcome the bottleneck of client-server and to relieve core networks from redundant transmissions. Nevertheless, since relying on unreliable end-users, ALM systems are more susceptible to node churn and DoS attacks, so that appropriate countermeasures and a careful system design are required. We describe the architecture of an IPTV system based on ALM, present a formal IPTV model and summarize several research challenges in such a scenario. Our system is intended to optimally adapt its resources to a changing user behaviour and to build topologies that are efficient and robust at the same time by minimizing reconstruction costs caused by changes in the user compound.

End of Lecture Session

C6 Systems and Network Security Doctoral Workshop

Time: Friday, 17.09.2010

Location: Humboldt-Building, Lecture Room 204

Chairmen: W. Kühnhauser, G. Schäfer (DE-Ilmenau)

9:00 a.m.	S. Malipatlolla, S. A. Huss (DE-Darmstadt)
A Novel Technique for FPGA IP Protection The configuration data sequence of a field programmable gate array (FPGA) is an intellectual property (IP) of the original designer. With the increase in deployment of FPGAs in modern embedded systems, the IP protection of FPGA hardware designs has become a necessary requirement for many IP vendors. There have been already many proposals to overcome this problem using symmetric encryption techniques but these methods need a cryptographic key to be stored in a non-volatile memory located on FPGA or in a battery-backed RAM (Random Access Memory) as done in some of the current FPGAs. The expenses with the proposed methods are, occupation of larger area on FPGA in the former case and limited lifetime of the device in the latter. In contrast, we propose a novel method which combines the dynamic partial reconfiguration (dynamic PR) feature of an SRAM-based FPGA with the public key cryptography (PKC) to protect the FPGA configuration files without the need to store any keys on FPGA. Using our method, not only the high-end FPGAs but also the low-end FPGAs with partial reconfiguration capabilities are secured. The proposed method has been implemented on a Xilinx Virtex-5 FPGA platform.	
9:20 a.m.	M. Meichau (DE-Ilmenau); S. Steinbrecher, St. Groß (DE-Dresden)
JASON: A Scalable Reputation System for the Semantic Web The recent development of the Internet, especially the expanding use of social software and dynamic content generation commonly termed as Web 2.0 enables users to find information about almost every possible topic on the Web. On the downside, it becomes more and more difficult to decide which information can be trusted in. In this paper we propose the enhancement of Web 2.0 by a scalable and secure cross-platform reputation system that takes into account a user's social network. Our proposed solution Jason is based on standard methods of the semantic web and does not need a central entity. It enables the fast and flexible evaluation of arbitrary content on the World Wide Web. In contrast to many other reputation systems it provides mechanisms to ensure the authenticity of web content, thus, enabling the user to explicitly choose information published by trusted authors.	
9:40 a.m.	R. Schmidt (DE-Eching); G. Schäfer (DE-Ilmenau)
Towards Efficient Resource Management for Vehicle-to-Vehicle Communications Reliability is one of the key requirements for Intervehicle communication in order to improve safety in road traffic. This paper describes the difficulties of Intervehicle communication being under high load. We focus on an analysis of the state-of-the art MAC protocol IEEE P802.11p and its limitations. With a simple model based on signal propagation and Signal-to-Interference ratio, we determine the theoretic reduction of the communication range. We further determine the network capacity which provides a quantification of the situation	

of high load on the channel. In a simulation experiment, we highlight that severe packet loss can occur. The communication range can be reduced by up to 90%. It is common trend to handle this problem by controlling the load on the channel in a decentralized manner. A common load metric, e.g. the channel busy time, is the key input parameter. We evaluate the correlation between the channel load metric and the actual reduction of the transmission range on average and in the worst case.

10:20 – 10:40 a.m. Coffee break

10:40 a.m. | A. Heinlein, G. Schäfer, M. Roßberg (DE-Ilmenau)

Secure Multicast in Internet-wide VPN

As more and more sensitive communication takes places over the Internet, security becomes a major objective in many areas. This lead to an extensive deployment of virtual private networks (VPNs) providing a cheap alternative to traditional dedicated lines by allowing private communications over public infrastructures. Despite being standardized for more than a decade, there is no efficient solution for distributed group communications in these scenarios. Network load increases equally to the number of participants as data has to be transmitted individually for every single recipient, leading to a waste of bandwidth and higher latency. Existing application-level multicast approaches have to deal with poor topologies, limited performance, and insufficient reliability as the VPN is not aware of the additional overlay and consequently cannot optimize it. Additionally, multiple multicast streams can lead to overloaded links as end-user applications can influence routing decisions only insufficiently. However, group communications are rather important in order to allow efficient distribution of video messages, audio streams and software updates.

Thus, realizing group communications by transparent IP-multicast is major challenge for dynamic VPN overlay services. Even though transferring the traditional peer-to-peer push approach to a VPN-based multicast overlay seems a straightforward approach, interesting detail problems occur, i.e., additional topology control mechanisms are needed to ensure good security and reliability properties. Our system, called STORM, is realizing a transparent, single-source multicast distribution tree for IP-multicast with the help of a number of distributed algorithms. It is able to rate nodes based on their age to efficiently integrate mobile nodes and make attacks on the availability more sophisticated. Further metrics like delay, bandwidth, and hop count can be considered to construct and optimize efficient topologies. Moreover, tree balancing will occur to reduce latency and improve reliability as well as resilience against random failures or specific attacks.

DoS resistant Distributed Time Synchronisation for Virtual Private Networks

Time synchronicity is an important basis for many processes in modern IT infrastructures. Digital signing of messages and temporary user tickets in a Kerberos environment are two examples, where synchronized clocks are desired. Focussing on designing an algorithm with robustness against attackers, any hierarchical or centralized approach must be disregarded. The most popular mechanism for the use in wired IP networks is the Network Time Protocol (NTP) [Mills, 2006] with a possible deployment in global scenarios. Apart from that, several synchronization methods exist for local area networks, like dedicated cluster heartbeat infrastructures. The last-mentioned mostly making a use of MAC-Layer access for a preferably high accuracy. Also distributed algorithms sometimes using a hierarchical structure for propagating the synchronization data. Thus, a denial-of-service (DoS) attack is possible by compromising nodes, that act as an initiator, or nodes with a high number of children. Therefore, a solution for this problem must be a fully distributed approach without any hierarchical needs. Inside of a VPN infrastructure, some important security goals are realized inherently. Communicating nodes are authenticated against each other and the transfer of data is confidential and integer. This is a big advantage over other use cases, because of the impossibility of attacks like modification, eavesdropping or replaying. In this paper, we describe a new distributed approach for a secure time synchronization method without DoS vulnerabilities. The NTP-Protocol can be used to ensure the global synchronicity between VPN and surrounding. Even if no NTP-Server is available, the synchronization of all inner nodes is guaranteed. Furthermore, we will show the ability to adapt the node's local clock-drift to the network, what results in a stable behaviour in the case of a temporarily partitioned scenario, where no communication between the separated subnets is possible. Several attacker models (internal and external) are used to evaluate the robustness of the algorithm. Simulation results and realtime measurements are proving the ability to defend external delay attacks, as well as the robustness against a certain percentage of internal attackers.

12:00 noon – 1:30 p.m. Lunch

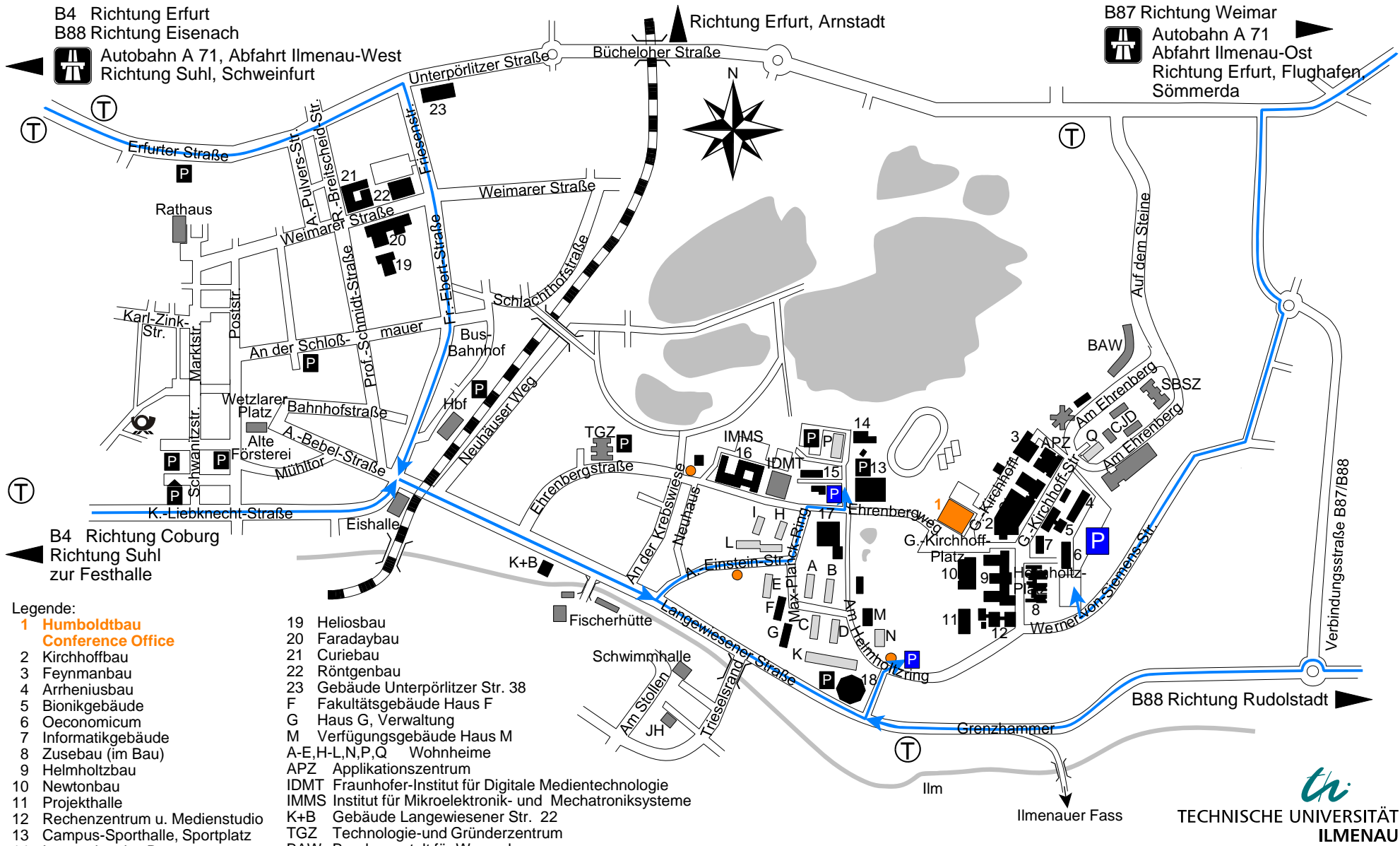
End of Lecture Session

C6 Systems and Network Security Doctoral Workshop

Time: Friday, 17.09.2010, 11:20 a.m.

Location: Humboldt-Building, Lecture Room 204/Foyer

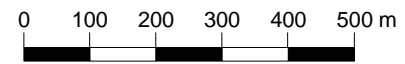
Poster Session:
Chairman: W. Kühnhauser, G. Schäfer (DE-Ilmenau)
Pham Van Thuong, Hoang Dang Hai, Ha Duong Nguyen (VN-Hanoi)
Design and Deployment of a Monitoring Sensor for Enterprise's Networks
Enterprise's computers that are connected to the Internet are often targets for attacks and need to be protected. Using sensors, a network security monitoring system can collect security events from different locations in the network, analyze them and give indications of possible network attacks. However, it is still not clear how a sensor network can be designed and how can the sensors be managed. This paper presents an approach for modeling a sensor management system within an enterprise's network security monitoring framework. We discuss the overall architecture of sensor networks as well as several factors that influence the sensor network design and present a framework for a sensor management system.



Legende:

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- 6 Oeconomicum
- 7 Informatikgebäude
- 8 Zusebau (im Bau)
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- 14 Internationales Begegnungszentrum (IBZ)
- 15 Hörsaal 2
- 16 Ernst-Abbe-Zentrum, Rektorat
- 17 Mensa, Akademisches Service Center (ASC)
- 18 Leibnizbau, Universitätsbibliothek

- 19 Heliosbau
- 20 Faradaybau
- 21 Curiebau
- 22 Röntgenbau
- 23 Gebäude Unterpörlitzer Str. 38
- F Fakultätsgebäude Haus F
- G Haus G, Verwaltung
- M Verfügungsgebäude Haus M
- A-E,H-L,N,P,Q Wohnheime
- APZ Applikationszentrum
- IDMT Fraunhofer-Institut für Digitale Medientechnologie
- IMMS Institut für Mikroelektronik- und Mechatroniksysteme
- K+B Gebäude Langwiesener Str. 22
- TGZ Technologie- und Gründerzentrum
- BAW Bundesanstalt für Wasserbau
- SBSZ Staatliches Berufsschulzentrum
- CJD Christliches Jugenddorf
- JH Jugendherberge
- Orientierungstafeln



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