Fraunhofer
ITWM

FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS ITWM

ANNUAL REPORT 2012/13

EDITORIAL NOTE

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This annual report is also available in german language.

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Photography The editors wish to thank all cooperating partners for placing the corresponding photos at their disposal.
FCC Gothenburg (S): pages 86, 87
Fotolia: page 59
iStockPhoto: pages 56, 58
MEV: pages 50, 67
Photos: Fraunhofer ITWM, Gesa Ermel

Printing Kerker Druck GmbH, Kaiserslautern

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PREFACE

The year 2012 was another very successful one for ITWM, with further growth of 18 percent in the budget and 31 new staff members. This was due in large measure to the rebounding of the markets. The industry revenues of 9.5 million euros were the highest since the establishment of ITWM and contributed business income that equaled a 45.1 percent share of the total budget of 21 million euros. The guaranty for the sustained economic and scientific success at the institute is the highly motivated staff. At this occasion, let me express my appreciation for their outstanding efforts in achieving the aims of ITWM and their strong identification with the work performed here.

Growth creates the need for space. In 2012, our extension building was ready for occupancy after only 19 months of construction (details on page 6), which provided outstanding conditions for further expansion of the competences and business segments at ITWM. On the occasion of the festive opening ceremony, state Education Minister Doris Ahnen spoke of the importance of the expansion of the institute to the profile of Kaiserslautern as a center of education and research.

All departments of ITWM showed positive operating results for the year 2012, some of them reporting growth well above average. For example, the Competence Center for High Performance Computing increased its operating budget by 45 percent. Contributing for the first time to such a large extent are the projects mySmartGrid and myPowerGrid, which are developing the optimized use of PV generated electricity in private homes. The software products Pre-StackPRO and Fraunhofer File System FhGFS have continued their outstanding development. The growing acceptance of these tools for developing parallel software has allowed the HPC specialists to greatly expand their position in the oil and gas market.

The Mathematical Methods in Dynamics and Durability department continued its development of the technology for the simulation of Vehicle-Environment-Human-Interaction in a new innovation cluster of the same name. In this context, the new geo-referencing system for vehicle development – Virtual Measurement Campaign – was installed for the first time by industry partners DAF, Daimler, MAN, Scania, and Volvo. The IPS Cable Simulation software platform for planning the virtual assembly of deformable cables and hoses has been marketed and distributed by the spin-off company fleXstructures GmbH since 2012.

The Optimization department reported a 25 percent increase in earnings over the previous year and is financially very well positioned with a 50 percent share of the business returns. The high points of the year were the continuation of a project for the optimal layout of photovoltaic power plants for Siemens AG, the continuation of the project for multi-criteria optimization of chemical process design, and the transfer of a long term cooperation agreement in the area of radio therapy planning from Siemens Health Care to RaysearchLabs, Stockholm.

The Transport Processes department made significant advances within the scope of projects for the production of filaments and non-wovens. This is evidenced by three highly successful end-of-year promotions as well as the complete re-engineering of the core software FIDYST (Fiber Dynamics Simulation Tool) to a new basis which now permits the mapping of complex scenarios for the production of non-wovens. In the field of grid free methods, FPM software increasingly demonstrated its superior qualities as a general simulation tool for problems of continuum mechanics.

The Flow and Material Simulation department continued its pioneering role in the development of industrial multiscale and multi-physics methods. Furthermore, a breakthrough was made in the area of micro-mechanics with the release of the robust FFT-based solver FeelMath, which is more efficient by several orders of magnitude compared to commercially available FE packets. The so called FE^2 method, which performs simulation and optimization of porous components and composite structures while taking into account the properties of the local microstructure, was prepared for initial use in industrial applications.

In 2012, the Image Processing department managed more projects in one year than ever before. The trend towards hundred percent quality control requires new, innovative solutions all the time, especially, in the area of image processing. The applications are not limited to the visual spectrum: there is an increasing demand for imaging by means of x-ray computer tomography, ultrasound, and other technologies. The core competence is the development of algorithms and software suitable for large-scale industry applications; for use as systems as well as separate software packages.

The Financial Mathematics department expanded their core competences and started new and innovative research in 2012. This included a completely new electricity price model tailored for a German market sharply influenced by alternative energies, the design and implementation of a comprehensive risk management system for asset management, and cooperation agreements with firms and researchers in generating an energy saving hardware-implementation of Monte Carlo code for use in the financial sector.

The System Analysis, Prognosis, and Control department entered a new field of promising industrial activity for processing demanding modeling and simulation problems in the context of hardware-in-the-loop testing of control and monitoring devices for complex technical systems. Furthermore, the advanced development of "Design" as a stand-alone software tool for data-based prognosis and analysis of the interactions between parameter settings with various product qualities is proceeding and was successfully used for the first time to generate behavioral models of electronic circuits.

Allow me at the conclusion of my foreword to say a few lines that address topics beyond the ITWM area of responsibility. In my function as chairperson of the Scientific and Technical Advisory Board of Fraunhofer-Gesellschaft, I am continuously exchanging ideas with staff members at our institute and the headquaters in Munich, with members of the steering committee, and the executive board of Fraunhofer-Gesellschaft.

Of course, there will always be varying conceptions regarding how basic funding should be allocated, how the development strategy is formulated, what the priority topics of Fraunhofer should be, when to use appropriate personnel management tools, and many, many, more subjects where the possibility of a conflict of interest exists. It is sometimes rather strenuous, but what always gives me strong motivation in my work is the exceptional solution-oriented culture of the discussions and constructive argumentation, the willingness to find compromise, a perceived and vibrant Corporate Identity with an extremely high level of identification with the objectives and the mission of Fraunhofer-Gesellschaft and – last but not least – my pride in being a part of this strong group. I would like to thank my colleagues at Fraunhofer-Gesellschaft cordially for their faithful and constructive cooperation over the past years.

I hope you enjoy our annual report and express my sincere appreciation to all project partners for their constructive support and pleasant cooperation.

Prof. Dr. Dieter Prätzel-Wolters
Director of Fraunhofer ITWM

OPENING CEREMONY FOR NEW BUILDING

1 *Centerpiece of the new atrium is the RoboLab (pictured here without the dome)*

2 *All speakers at a glance: The Rhineland-Palatinate Education Minister Doris Ahnen flanked by Lord Mayor Klaus Weichel, President of the University Helmut Schmidt, ITWM Director Dieter Prätzel-Wolters, BMBF councilor Paul Hocks, Fraunhofer Senior Vice President Alfred Gossner, and architect Horst Ermel (LTR)*

19 months building time, 2000 square meters floor space, 110 new workplaces, 11.6 million Euros – these are the plain facts about the ITWM extension project. The building houses new labs, modern offices, and an outstanding IT infrastructure – all things that provide a substantial gain to the quality of work. The construction was financed by the state of Rhineland-Palatinate, Fraunhofer-Gesellschaft (25 percent), and European Structural Fonds for Regional Development (EFRE, 50 percent) and complements the three wings of the institute by adding a building that harmoniously connects to the main building via the attractive atrium. The new, five-story building with its all glass facade facing to the city sets a final architectural accent to the ITWM complex. The ITWM staff occupied their new offices in May, with the official opening ceremony following in August.

The institute director, Prof. Dieter Prätzel-Wolters, praised the excellent working environment at ITWM and highlighted the outstanding start position for an expansion of competences and business segments adding: "During these challenging economic times, we do not take this investment in research and innovation for granted, when in many countries of Europe, universities and research institutes have to suffer greatly from mandatory budget constraints. We are benefitting and appreciate the facts that federal and state governments place a high priority on such investments and, that through its successful work, Fraunhofer-Gesellschaft is in a position to provide considerable resources for the expansion of its institutes."

The State Education Minister Doris Ahnen spoke of the importance of the expansion of the institute to the profile of Kaiserslautern as a center of education and research. "I am confident that the investment in the new building was a good decision. These new job opportunities enable ITWM to further expand many of the innovative developments in application-oriented mathematics, which are respected well beyond the borders of the state."

Prof. Dr. Alfred Gossner, Senior Vice President at the Fraunhofer-Gesellschaft, thanked all who participated in the "ITWM-building expansion" project and emphasized the importance of the Fraunhofer Innovation Cluster "Digital Commercial Vehicle Technology (DNT): "The major aim of this innovation cluster is to strengthen the regional R&D competencies related to the commercial vehicle segment. The cluster improves the competitive position of the participating companies on the European and global markets and, for that reason, makes a sustainable contribution to safeguarding jobs in the region."

A substantial contribution to the workings of this innovation cluster is accomplished by the centerpiece of the new atrium, the **RO**bot based **D**riving and **O**peration **S**imulator RODOS®,

which consists of the control center and swivel-mounted cab in original size. In the overarching dome, various work environments can be simulated, typically, scenarios for construction machinery. The focus, however, is on the human as the operator, whose behavior greatly effects the service life of the machinery – and that is what distinguishes RODOS. In the past, the human was neglected in the simulations. Also benefitting from the new building is ITWM's Ultrasonic imaging department. The new building provides much needed lab space and a better framework for the conduct of research in the testing and inspection of oversized and heavy components, for example, large ship propellers

1 *High tech product in field operations*

2 *Future schedulers busy placing orders: Who can plan better than a computer?*

2. INTERNATIONAL COMMERCIAL VEHICLE SYMPOSIUM

In March, ITWM was among the sponsors of the International Commercial Vehicle Symposium, held for the second time at TU Kaiserslautern, which underscored the importance of the research center to the commercial vehicle industry and its technological development. Representatives from the research and industrial communities agree: trucks, farm, and construction machinery have become high tech products with many demanding challenges for engineers, computer scientists, and mathematicians. A major topic was Vehicle-Environment-Human Interaction: The work at the ITWM Robot based Driving and Operation Simulator contributes to the optimal design and support of commercial vehicle operator compartments. Other topics included improving energy and resource efficiency as well as ensuring safety and reliability.

ITWM AT IDEAS PARK ESSEN

How can hospital waiting times – and the corresponding daily annoyance of patients and transporters alike – be reduced? One solution was presented by Fraunhofer ITWM at the World of Technology "Idea Park" held at the trade show facilities in Essen. The "Patient-Navi" is a game variant of the optimization software Opti-TRANS. The very realistic simulation of a routine hospital day attracted many visitors to the stand who tried, with a lot of energy, to do a better job at scheduling than the computer. As just one of several hundred exhibits, the "Patient-Navi" was able to convince the predominantly young crowd of visitors that technology and the natural sciences can be very exciting. In just under two weeks, approximately 320,000 visited the Idea Park in August.

"THE BROADER VIEW" – AN INTERDISCIPLINARY LECTURE SERIES AT THE FELIX KLEIN CENTER

Once a month, the Felix Klein Center, an institutional pooling of resources from Fraunhofer Institute for Industrial Mathematics and TU Kaiserslautern, hosts the lecture series "The Broader View" ("Blick über den Tellerrand"). What is meant is the broader perspective, the view beyond the isolated scientific disciplines. This view finds expression in the form of lectures covering many diverse disciplines. The aim is to extend the scientific horizons of both organizations: members of the Felix Klein Center are encouraged to look "outside" to the people who live "outside", to think "outside" the box of their routine work at the Felix Klein Center.

The series has been able to attract well-respected historians, philosophers, educators, sociologists as well as mathematicians who give amateurs an impression of the inner workings of the Felix Klein Center. Among the lecturers, for example, is Prof. Dr. Michael Hassemer, from the department of civil law, business law, and intellectual property at TU Kaiserslautern, who focuses on the commercialization of intellectual property, especially, the issue of how copyrights can still work in a digital age.

Another discussion centers on the freedom of research from the perspective of a journalist; scientific journalist Volker Stollorz directed the attention of the audience to the tensions between the right of the public to information and the desire of science for unrestricted research. Prof. Horst Ermel, head of the architecture firm that planned Kaiserslautern's Fraunhofer Center, believes in the motto "science generates architecture" and concentrates on design strategies for R&D facilities. Of course, the agenda includes talks on current topics in mathematics: "Mathematik zwischen Forschung, Anwendung und Vermittlung" (Prof. Dr. Gert-Martin Greuel, TU Kaiserslautern), "Mathematik – ein polarisierendes Schulfach! Welche Rolle kann und soll Mathematik in einem zeitgemäßen Schulunterricht spielen?" (Prof. Dr. Gabriele Kaiser, University Hamburg) or "Der Mathematiker als CEO – Segen oder Fluch?" (Dr. Frank Gropengießer, Mathematiker and Ex-CEO).

The selected lectures illustrate the broad bandwidth of topics which are worth considering from the broad view – regardless of where you are standing when you look outside. A follow-on series is being planned.

1 *"Politik steuert Wissenschaft: Ein Mythos?" (Prof. Dr. Frieder Meyer-Krahmer, retired state secretary of the German Federal Ministry of Education and Research)*

2 *"Genom-Forschung zwischen Ethik und Kommerz am Beispiel des CCR5-Gens" (Professor Myles W. Jackson, New York University)*

3 *"Mit allem rechnen – Zur Philosophie der Computersimulation" (Dr. Johannes Lenhard, University of Bielefeld)*

FRAUNHOFER ITWM

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INSTITUTE PROFILE

Computer simulations are an indispensable tool in the design and optimzation of products and production processes, services, communication processes and work processes. Real models are replaced by virtual models. Mathematics plays a fundamental role in the creation of this virtual world. Mathematical models cut horizontally across a landscape of vertically arranged scientific disciplines and technological applications. This transverse character of mathematics makes it a "generic technology"; as a basis for bridging into the simulation world, however, it also becomes the key technology for computer simulations which have found their way into nearly all areas of economic life. Increasingly more small and medium-sized companies utilise simulation for cost reduction. It is specifically these companies that the Fraunhofer ITWM supports with consultation and computing power. They profit in the market through the use of simulation as identification for innovation and quality assurance of their products.

Of course, we also work together with large companies, especially in the motor vehicle sector, in machine construction, the textile industry, in microelectronics, with banks and the computer industry. Consultation in R&D questions, support in the use of high-performance computer technology and provision of custom-tailored software solutions are integral building blocks of our work.

Along with the implementation of this technology in application projects and its further development in research projects, the close collaboration with the Department of Mathematics at the University of Kaiserslautern is also a point of emphasis for the Fraunhofer ITWM. The classical disciplines of applied mathematics such as numerics, optimization, stochastics and statistics as well as differential equations are cornerstones.

The specific competences of the ITWM are

- Processing of data acquired from experiments and observations
- Drafting of mathematical models
- Implementation of mathematical problem-solving in numerical algorithms
- Summarization of data, models and algorithms in simulation programs
- Optimization of solutions in interaction with the simulation
- Visualization of simulation runs in images and graphics

The ITWM is member of the Fraunhofer ICT Group as well as associated memeber in the Fraunhofer Group for Materials and Components – MATERIALS. In addition, the good networking within the Fraunhofer-Gesellschaft documents the participation in numerous Fraunhofer Alliances: Automobile Production, Adaptronics, Battery, Cloud Computing, Lightweight Structures, Simulation, Traffic and Transportation, and Vision (image processing).

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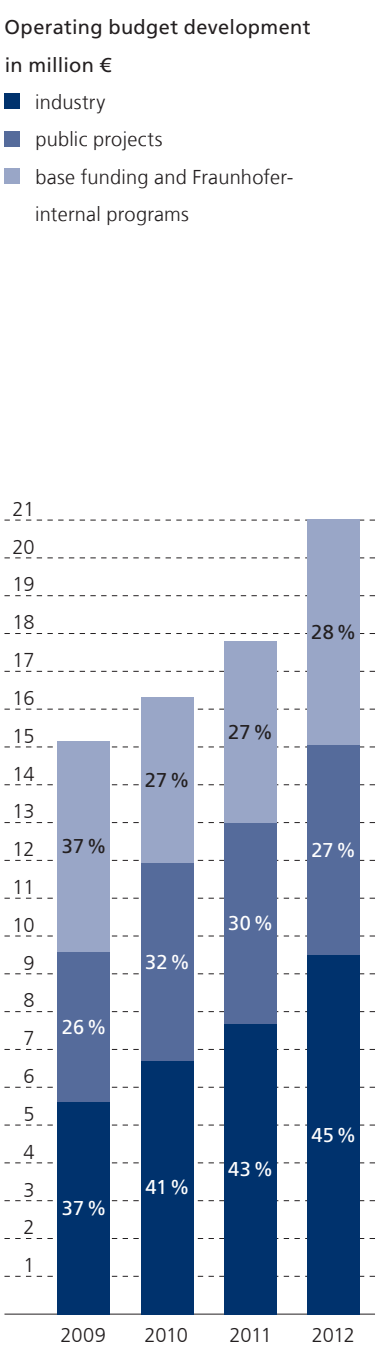
Klaus Linck, Michael Mannweiler, Michaela Grimberg-Mang, Markus Pfeffer, Anja Nitschky, Katharina Parusel, Manuela Hoffmann, Dr. Marion Schulz-Reese, Prof. Dr. Dieter Prätzel-Wolters, Prof. Dr. Helmut Neunzert, Elke Münch, Brigitte Williard, Claudia Nickel, Sabine Müller, Prof. Dr. Axel Klar, Prof. Dr. Stefan Nickel

BUDGET

Operating budget development

in million €



There were already early indications that 2012 would be another very successful year for ITWM. We were able to occupy the new institute building, our operating budget increased by 18 percent and the share of revenues from industry customers was at 45.2 percent, one of the highest in the last 10 years. Industry revenues increased from 2011 by an incredible 23.6 percent to more than 9.5 million Euros. A contributing factor in this was the share of international orders which also continued to increase. Meanwhile, these orders have reached 36 percent of the total industry revenue. Overall, ITWM was able to rely on its regular customers as well as being pleased about the contracts awarded by a large number of new customers. Among our largest customers in 2012 were Statoil, Daimler, Siemens, and BASF. The area of public funding was subject to a slight decrease compared to 2011. The income from BMBF actually, decreased by more than 20 percent. The gap for 2012 could be filled by an increase in financial funding from the states. In light of the debt caps in the public coffers, the forecasts for the coming years are generally unfavorable. Even the grants from internal Fraunhofer programs closed out the year with a 14 percent minus compared to 2011.

The outlook for 2013, however, is very positive. As early as March, the order book in 2013 already reflected 72 percent of the planned annual income indicating that further growth is necessary, especially, in the human resource area.

Budget development*	2009	2010	2011	2012
Operating budget	15170	16315	17810	21034
Investments	894	550	2567	1042
Total	**16064**	**16865**	**20377**	**22076**

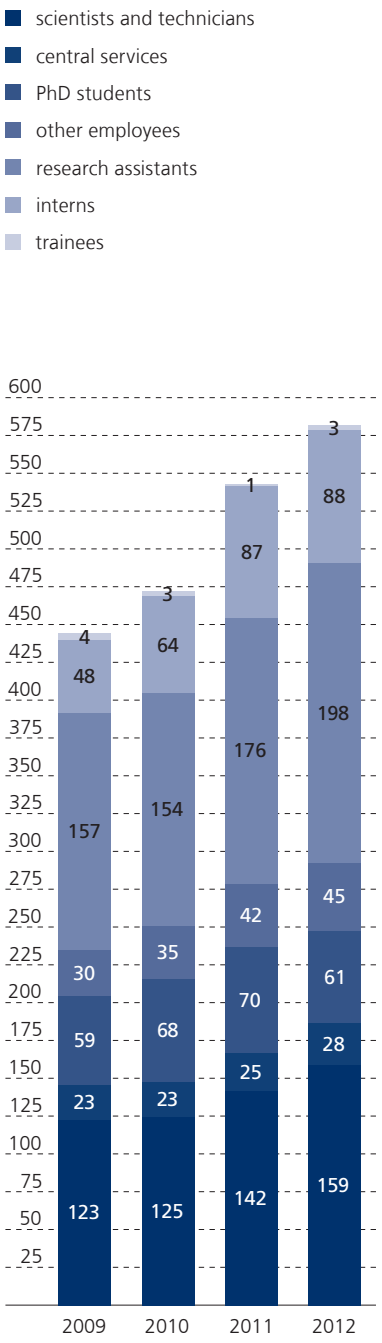
*thousand €

PERSONNEL DEVELOPMENT

As a result of the excellent order situation in 2012, the strong personnel growth at ITWM continued. There were 31 new members of the staff hired, versus 14 who departed from ITWM. It is noteworthy that nearly half of those who left went to one of the ITWM spin-off firms. Also worthy of mention is the fact that the percentage of women at ITWM is increasing, nearly 40 percent of the new hires in the research area were women.

A very pleasant trend continued from the year 2011 and that is, more than half of the new research scientists were drawn from within the institute itself. It is becoming increasingly evident that the various secondary schools projects and the intensive support provided to students at the department of Mathematics at TU Kaiserslautern by ITWM, are an extremely important component in the human resource recruiting effort over the mid- and long-terms. The successful strategic alliances with TU Kaiserslautern, such as the Mathematics Initiative, the Kaiserslautern Innovation Center Science Meets Engineering, and the Felix Klein Center for Mathematics have already proved to be very productive recruiting grounds for ITWM.

The completion of the new building in May 2012, was of major importance for the strong growth of ITWM. The extremely cramped working conditions of recent years are, fortunately, now a thing of the past. The new space is already being used at near capacity, an indication that with continued growth being highly likely, another expansion may be on the horizon for ITWM in the near future.



COSTUMERS AND COOPERATION PARTNERS SELECTION 2012

- Abbott GmbH & Co. KG, Ludwigshafen
- Accenture CAS GmbH, Kaiserslautern
- Aixprocess GmbH, Aachen
- ante-holz GmbH, Bromskirchen
- AUDI AG, Ingolstadt
- AUTEFA, Linz (A)
- Avid Technology GmbH, Kaiserslautern
- BASF SE, Ludwigshafen
- Bayerisches Staatsministerium der Finanzen, München
- BMW Group, München
- BPW Bergische Achsen Kommanditgesellschaft, Wiehl
- Bundesanstalt für Materialforschung und –prüfung, Berlin
- Centre de Recherche en Automatique de Nancy, Nancy (F)
- ClusterVision, Amsterdam (NL), München
- Continental, Frankfurt/Main
- DAF Trucks N. V., Eindhoven (NL)
- Daimler AG, Stuttgart
- Delta Computer, Reinbek bei Hamburg
- Demac, Wolkenstein (I)
- Det Norske Oljeselskap, Oslo (N)
- Deutsche Apotheker Bank, Düsseldorf
- Deutscher Sparkassen- und Giroverband, Berlin
- Deutsches Krebsforschungszentrum, Heidelberg
- EKF diagnostic GmbH, Barleben
- ESI Group, Paris (F)
- evico GmbH, Dresden
- First Quality Nonwoven Inc., Hazle Township (USA)
- FLSmidth Wadgassen GmbH, Wadgassen
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- Fujitsu / ICT, Aachen
- Grau Data, Schwäbisch Gmünd
- Heidelberger Ionen Therapie GmbH, Heidelberg
- Heimbach GmbH & Co. KG, Düren
- Hilite International, Nürtingen
- Hospitals: Bremen, Dachau, Essen, Franfurt-Höchst, Heidelberg, Homburg
- Hubert Stüken GmbH & Co. KG, Rinteln
- Hüttenwerke Krupp Mannesmann, Duisburg
- IBS FILTRAN GmbH, Morsbach-Lichtenberg
- Intel / BMW, München
- John Deere, Mannheim und Kaiserslautern
- Johns Manville Europe GmbH, Bobingen
- Juwi Holding AG, Wörrstadt
- K+S Kali, Phillippsthal
- Keiper GmbH & Co. KG, Kaiserslautern, Rockenhausen
- KTM-Sportmotorcycle AG, Mattighofen (A)
- Leder- und Gerberschule Reutlingen e.V., Reutlingen
- Liebherr, Kirchdorf, Colmar (F)
- LKC Wirtschaftsprüfer, Rechtsanwälte, Steuerberater, München
- MAN Truck & Bus Deutschland GmbH, München
- Mann+Hummel GmbH, Ludwigsburg
- Marathon Oil, Houston (USA)
- Massachusetts General Hospital (MGH) / Harvard Medical School, Boston (USA)

- Math2Market GmbH, Kaiserslautern
- Megware, Chemnitz
- Micobuss Software GmbH, Essen
- Mines Paris Tech, Paris / Fontainebleau (F)
- MTU Aero Engines GmbH, München
- MVZ Dres. Englmaier, Waldkraiburg
- Neoperl GmbH, Müllheim
- NOGRID GmbH, Mainz
- Oerlikon Neumag, Neumünster
- Paul Wild OHG, Kirschweiler
- Pfalzwerke, Ludwigshafen
- Porsche AG, Weissach
- proALPHA Software AG, Weilerbach
- Procter & Gamble, Schwalbach; Euskirchen, Cincinnati (USA)
- Progress Rail Inspection & Information Systems, Bad Dürkheim
- R+V Versicherung, Wiesbaden
- Reckitt Benckiser Produktions GmbH, Ludwigshafen
- Repsol, Houston (USA)
- Robert Bosch GmbH, Stuttgart
- Roche Pharma AG, Grenzach-Wyhlen, Pensberg
- Rock Solid Images, Houston (USA)
- Rolls-Royce Deutschland Ltd & Co KG, Oberursel
- Salzgitter Mannesmann Forschung GmbH, Duisburg
- Scania CV AB, Södertälje (S)
- Schmitz Cargobull AG, Altenberge
- Schott AG, Mainz
- Seismic City, Houston (USA)
- SIEDA GmbH, Kaiserslautern
- Siemens AG, Energy Sector, Nürnberg
- Siemens AG, Oncology Care Systems, Heidelberg
- Spring Energy, Oslo (N)
- Stadtwerke Kaiserslautern, Kaiserslautern
- Statoil, Stavanger (N), Trondheim (N)
- Stryker GmbH & Co KG, Freiburg
- Transtec, Tübingen
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NETWORKING AND COOPERATIONS

ITWM is integrated in a network of national and international partnerships and a member of several associations within the Fraunhofer-Gesellschaft:

- Fraunhofer ICT Group
- Fraunhofer Group for Materials and Components – MATERIALS (as associated member)
- Fraunhofer Automobile Production Alliance
- Fraunhofer Battery Alliance
- Fraunhofer Cloud Computing Alliance
- Fraunhofer Lightweight Structures Alliance
- Fraunhofer Simulation Alliance
- Fraunhofer Traffic and Transportation Alliance
- Fraunhofer Vision Alliance
- Fraunhofer Innovation Cluster "Digital Commercial Vehicle Technology"

Further cooperations

- Innovation Center »Applied System Modeling«

The Fraunhofer institutes IESE, ITWM, IPM (Terahertz Measurement Technology department) as well as the departments of Computer Science and Mathematics at TU Kaiserslautern work in close cooperation at ASM to bring high tech products to market quickly.

- Center for Mathematical and Computational Modeling

$(CM)^2$ co-located in the Mathematics department of TU Kaiserslautern, is focused on mathematical applications in the engineering sciences.

- Felix Klein Center for Mathematics

The FKZM is an institutional pooling of resources from the Math department at TU Kaiserslautern and Fraunhofer ITWM, with a focus on the promotion of young researchers, to include modeling weeks for schools, scholarships, and a mentor program for students of mathematics.

- Science Alliance Kaiserslautern

Network of academic and research institutes in Kaiserslautern.

THE FRAUNHOFER-GESELLSCHAFT AT A GLANCE

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and independent research units. The majority of the more than 22,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.9 billion euros. Of this sum, more than 1.6 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.


501/1

TRANSPORT PROCESSES

- FLEXIBLE STRUCTURES
- FLUID DYNAMICS
- GRID-FREE METHODS
- OPTICS, RADIATION, HEAT
- MODEL REDUCTION

Head of Department
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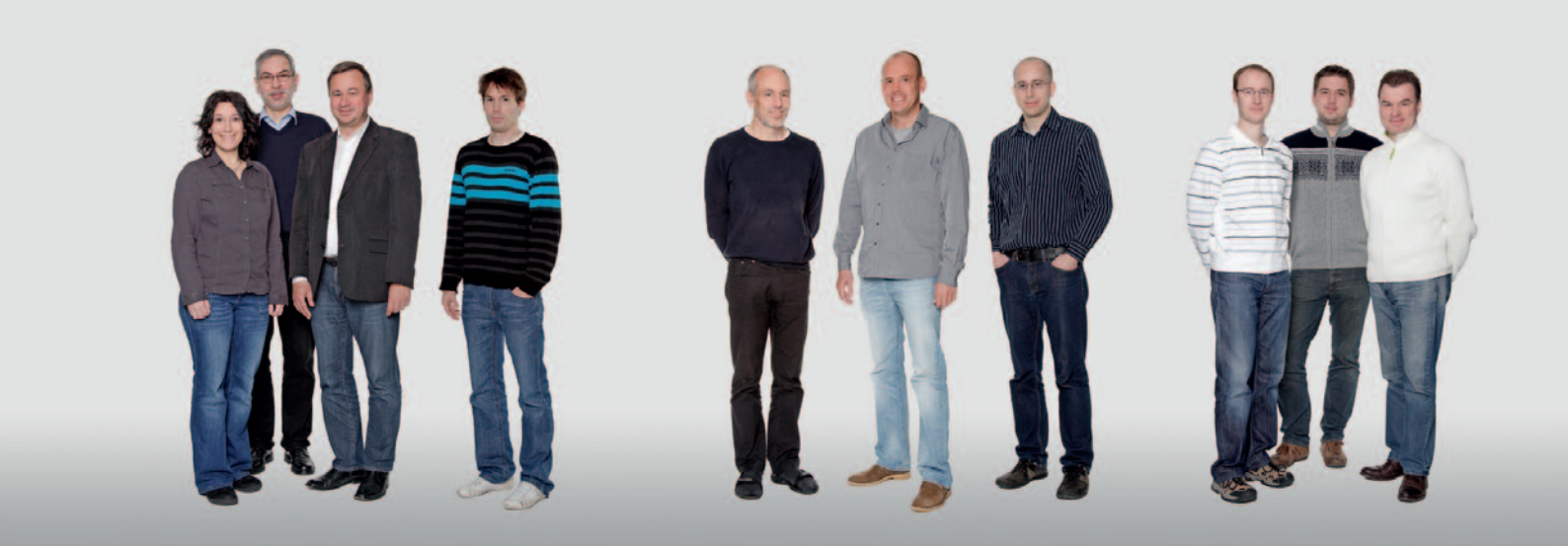
The core competence of the Transport Process department is the mathematical modeling of complex industrial problems and the development of efficient algorithms for numerical solutions (simulation). The problem areas outlined below are found in the technical scientific field (fluid dynamics, radiative transfer, optics, acoustics, structural mechanics, etc.) and from the point of view of mathematics, can lead to partial differential equations that are mainly characterized as transport algorithms. Our industry customers are primarily interested in the optimization of products or the technical designs of manufacturing processes. The department provides services and products that range from collaborative research projects with the R&D departments of our business partners with a focus on the engineering sciences to studies including design and optimization proposals, concept development, and software development. The year 2012 was very successful for all groups in the department, both professionally and economically.

Flexible Structures

The Flexible Structures group concentrates on modeling and numerical simulation of flexible (elastic, viscous, or viscoelastic) objects, especially, on the dynamics of filaments in (turbulent) flows. After many years in development the FIDYST (Fiber Dynamics Simulation Tool) simulator underwent a complete redesign in 2012 and now has a brand new highly efficient algorithmic C++-core, an intuitive user interface and a flexible port to commercial flow solvers. FIDYST has been used successfully in numerous projects to optimize the design of industrial textile production processes (e.g., non-woven production, spinning processes). The actual FIDYST suite simulator was extended especially for spunbonded nonwovens to include stochastic models for fiber deposition and the generation of virtual nonwovens.

Fluid Dynamics

The core competence of this group covers the major areas of fluid dynamics on the basis of Navier-Stokes equations, i.e., the entire spectrum in terms of ratios like Reynolds or Mach number as well as various material models. Frequently, fluid-structure couplings or heat radiation are incorporated. By extending and expanding standard tools like FLUENT or CFX with our own specific routines, efficient and accurate solutions are available for current research problems. A major focus is the optimal design of geometries for extrusion flows based on the required wall shear stress distribution.



Grid-Free Methods

The department has developed its own independent software basis, the Finite Pointset Method (FPM), for completing simulation tasks in the broad spectrum of problems arising in the area of fluid and continuum mechanics. FPM is a particle method, which unlike traditional numerical methods such as Finite Element or Finite Volume, needs no meshing and thus no cross-linkage. This method is extremely well suited for solving time dependent problems where grid-based methods are limited by the need for remeshing. Some typical challenges are problems in fluid dynamics with free surfaces, multiphase flows, fluid-structure-interactions with strong changes in the computing domain or structure mechanical problems with substantial changes in structure.

Dr. Isabel Ostermann, Dr. Jörg Kuhnert, Dr. Elisa Röhrig, Andre Schmeißer, Dr. Christian Leithäuser, Dr. Jan Mohring, Johannes Schnebele, Thomas Cibis, Dr. Walter Arne, Maria Kobert, Simon Schröder

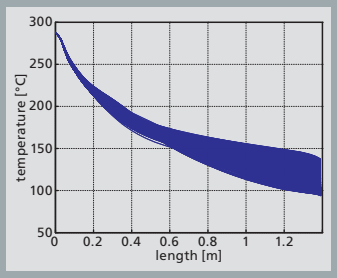
Optics, Radiation, and Heat

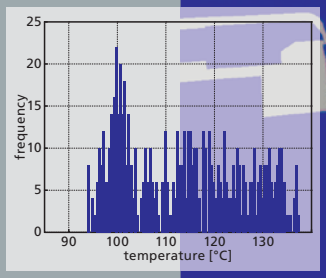
Freeform lenses or reflectors are used for specific area illumination in accordance with defined conditions. No additional dimming or projection elements are required, which means the optimal light effect is provided with a minimum of optics. But what must the surface of a lens or reflector look like to distribute the light so precisely? The Transport Processes department developed a very fast, robust algorithm and then implemented it in the software tool LODTa (Light Optimal Distribution Tool), which demonstrates the department's competence in solving so called "inverse problems". In addition to optic design and radiation in the visible range, other research priorities are radiation transport in the infrared range, heat transfer, and heat conduction.

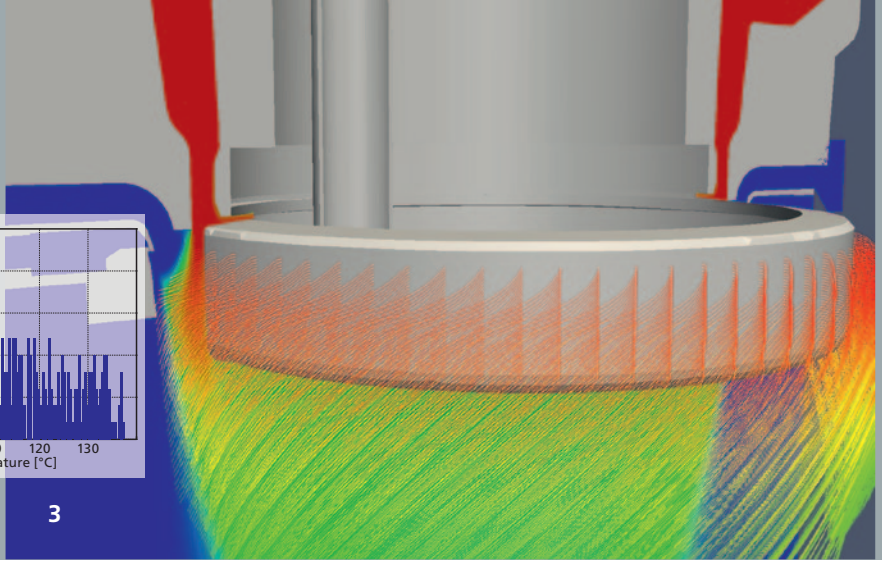
Dr. Simone Gramsch, Dr. Dietmar Hietel, Dr. Norbert Siedow, Florian Hübsch, Dr. Robert Feßler, Dr. Raimund Wegener, Johannes Maringer, Dr. Jevgenij Jegorov, Dr. Jalo Liljo, Sergey Antonov

Model Reduction

Today's technical products and processes can be simulated in great detail thanks to highly advanced software and increased computing power. However, developers are still not satisfied. They want more: variants have to be tested, evaluated quickly, and optimized. The key technology is called parametric model reduction, in which the original object, for example, a large Finite Element model, is converted to a parametric, reduced state-space model. These models can be evaluated much faster than the original model. The new parametric approach developed at ITWM solves two of the classic problems of reduction models: It is no longer necessary to start a new reduction for every new design parameter. Instead, the new parameter set is created by interpolation using a few pre-calculated reduced models – often in just a fraction of a second.







1 2 3

SIMULATION AND OPTIMIZATION OF SPINNING PROCESSES

1 Temperature curve of all fibers in a staple fiber spinning process (6.7 dtex) from ADVANSA

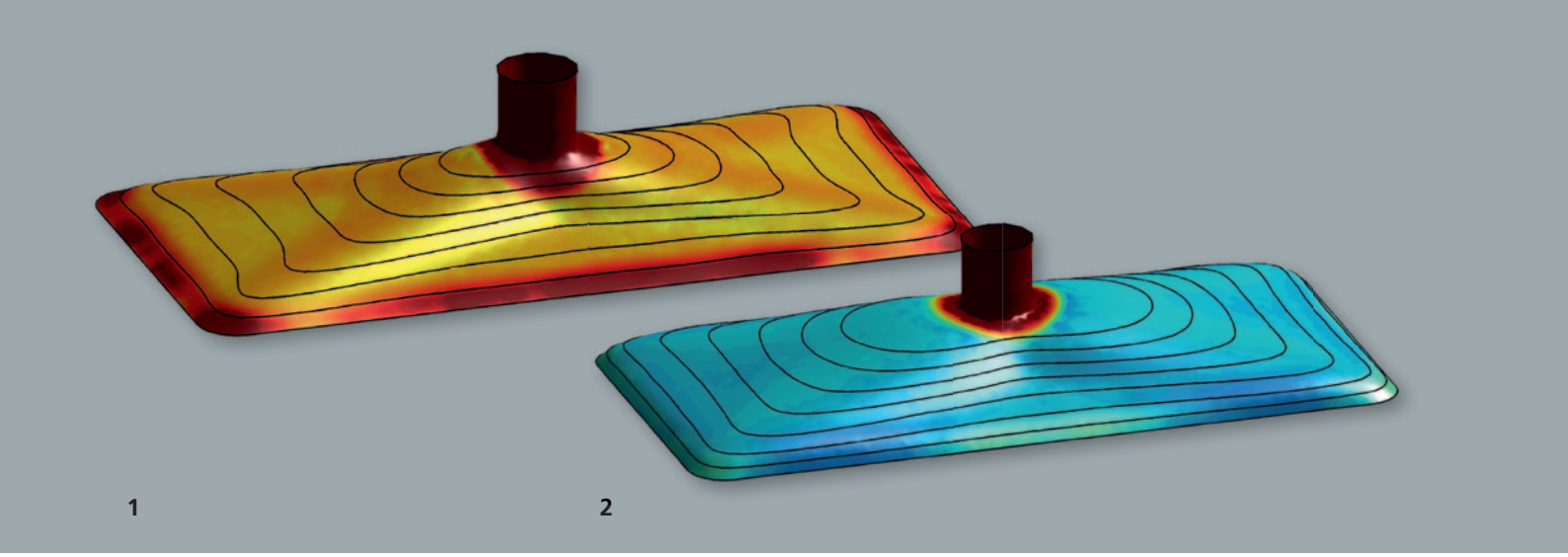
2 Temperature distribution on the roller in the staple fiber spinning process from ADVANSA. Consequent to the cooling by 150 degrees, the agreement between simulation and measurements is excellent - with an average of 110 °C versus 112 °C and a standard deviation of 12 K versus 14 K

3 Simulation of Woltz rotary spin processes in fiberglass production

After the molten polymer mass exits the spin packet, the spinning process becomes the real function defining step in the production process of fibers and filaments. The spectrum of application ranges from staple fibers and nonwovens to industrial textiles. The spinning process mechanically or aerodynamically accelerates the fibers to the required spin speed. The process quality depends most of all on the regularity of the fiber characteristics and the productivity.

In recent years, a series of research activities at Fraunhofer ITWM have provided the foundation for a comprehensive simulation of such spinning processes. The filament models based on the Cosserat theory, are based on a one-dimensional balancing of mass, impulse and energy along the filament for string models and additionally, the rotary angular momentum for rod models. The surrounding air flow produces a force on the filament and effects a thermal exchange with the filament. On the basis of analytical and experimental findings, ITWM has developed a universally applicable model for aerodynamic forces. The retroactive effect on the flow is based on the general “action equals reaction” principle. Homogenization conducts this to linear momentum and energy sources in the flow, realizable as UDF in flow tools like FLUENT. The result of the iterative linkage of fiber dynamics in MATLAB and the flow dynamics in FLUENT is a tool to simulate the entire interplay within the spinning process.

This simulation principle has been used in cooperation with industry partners for various spinning processes. The mechanically driven staple fiber spinning process at ADVANSA places the highest demands for regularity of the fibers and subsequently, the cooling process. As a result of the collaboration, a modified spinning process with improved regularity has been established. An aerodynamic spinning process is used by the Woltz Company in the production of fiberglass wool. In this process, the extrudate is first distributed onto a rotating disk as a glass film and then pressed out by centrifugal force through ten thousand holes and frayed out in a stream of air created by a hot gaseous flow near the disk and a surrounding curtain of cold air. The simulations demand a high precision coupling due to the aerodynamically determined filament curves as well as the coupling with the glass film on the inside of the rotor. The aim of the optimization process is the most suitable integration of the various throughputs per hole of the different rows and the significantly higher spinning speed on the upper rows as compared to the lower rows.



1 2

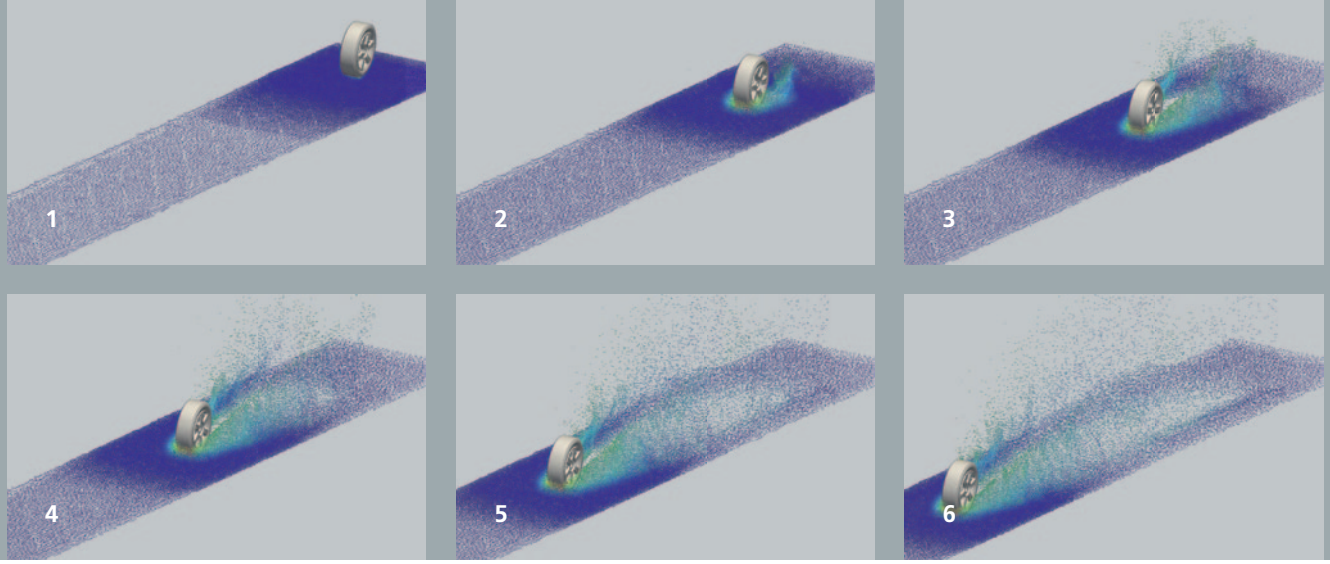
OPTIMAL EXTRUSION FLOWS

Spinning processes for the manufacture of non-woven fabrics and filaments are used in a wide range of product applications. Typically, the process chain consists of the production steps smelting, spinning, swirling, and deposit. The process begins as a molten polymer is pressed through the geometry of a spinneret onto a spinning plate. The spinning plate is composed of many fine capillaries, through which the filaments are spun. In the next step, these filaments are swirled, cooled, and deposited onto a conveyor belt for further processing as an end product. The product quality depends on the optimal interplay of all process steps.

1+2 *Two different designs of a spinneret with homogeneous wall shear stress (illustrated by color)*

Research activity focused on optimal extrusion flow is concerned with the polymer flows within such spinnerets as well as with the region around the spin plate. Since the polymer used for an actual spinning process can degenerate rapidly, it is essential for the product quality to keep the dwell time as short as possible. If the dwell time is too long, it can lead to degradations or premature cooling of the polymer and consequently, to poor quality filaments and even breaks in the fiber. In the worst case, individual capillaries or spinneret parts become clogged.

The optimal design of the spinneret, mathematically speaking, presents a shape optimization problem. A good quality criterion for a spinneret is the wall shear stress. This is a measure for the increase of the flow velocity in the region of the walls of the spinneret. A region where the wall shear stress is very low indicates an area with slow flow velocity, which leads to a longer polymer dwell time. Correspondingly, it makes sense to design the geometry of the spinneret to be free from regions of low wall shear stress. Conversely, problems can also arise when wall shear stress is too high, so to achieve an optimal spinneret design, the wall shear stress should be as homogeneous as possible. The method developed at ITWM facilitates the design of individual polymer distributors and, in the future, of colplete spin packs, for a wide spectrum of process parameters. The design geometries created on a computer can be checked with complex flow simulations in advance. In this way, the expected improvements can be verified prior to the actual construction. Successful industrial implementations demonstrate that this approach has major advantages over previous designs.



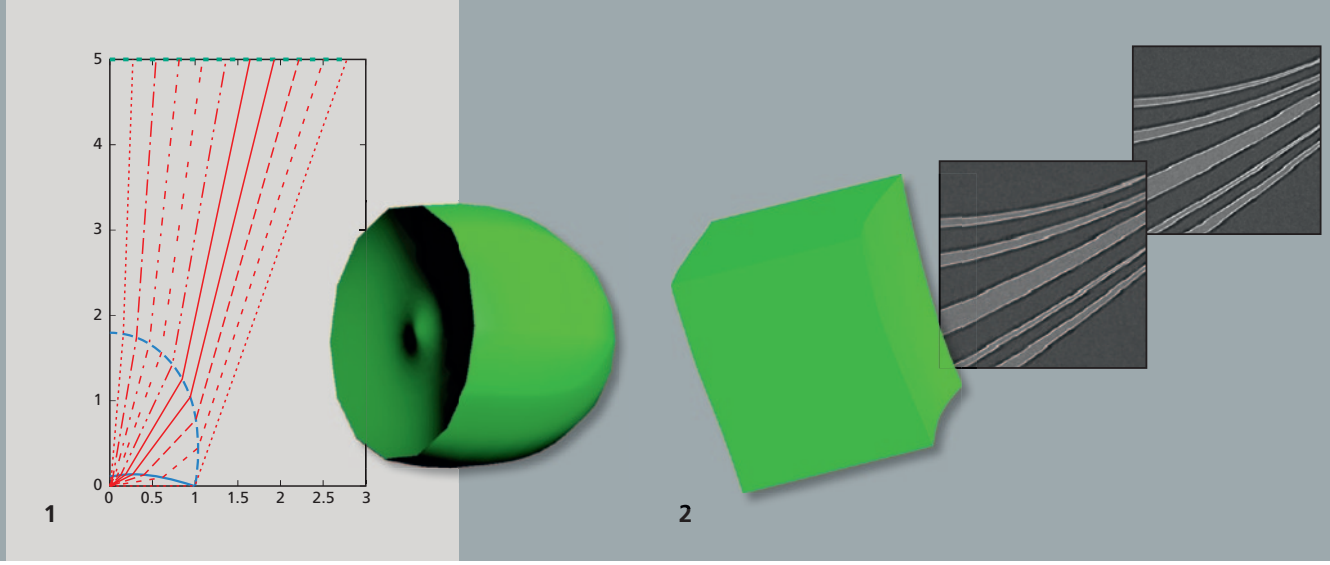
RAIN WATER MANAGEMENT FOR AUTO BODIES

1–6 *Spray formation passing through shallow water; starting point for studies of (rain)water transport on vehicles*

Rain is nature's motor. In some situations, however, rain water is not our friend: it leads to irritation or can cause damage. In this case, the simulation of rain water is not only a "nice-to-have", but rather a very practical tool in the development of technology that can be impaired by water.

Consider the example of an automobile. Rain water can cause damage when it enters hollow spaces, for example the doors, where it can start to corrode numerous existing electric and electronic devices. Rain water becomes a risk factor when dirty rain falls and smudges rear view mirrors and windows. Rain water becomes an irritation when it is constantly dripping from the tailgate into the trunk. Simulation can be used to spare the irritation as well as damage and provide safety. We think of rain water in the form of thin layers (puddles, pools of water) and also in the form of droplets. One form may transition over to the other form, as when many droplets on the tailgate are turned into a surge of water as a layer is formed when the trunk is opened. A stream of water flowing over a separating edge always forms into droplets. This dynamic is dominated by surface tension and the wetting angle of the water to the adjacent surface.

The overall aim is to achieve the most efficient simulation possible. This is the reason why the thin layers are not represented as a 3D solution, but rather with the aid of shallow water equations. However, droplets can only be numerically managed as a classic 3D image. In both cases, the basis for the simulation is the Finite Pointset Method (FPM). FPM is a grid-free approach especially well-suited for solving simulation problems with free surfaces. A very practical use of FPM is when the flow region a priori cannot be contained (i. e., it is impossible to know in advance where the droplet will land). The solution to the shallow water equation occurs on a point cloud, which only exists on the edge of the geometry, where it glides along like a thin film of water. The FPM solver for shallow water was an innovative development in 2012; theoretical water film thickness and velocity are the major integration variables. The droplet problem has a classic 3D FPM solution. The challenge consists in the integration of these phases. To the extent that a droplet can form from a shallow layer of water, the FPM numerics must also be able to produce a 3D phase from a shallow water solution. The same is true in reverse.



FREEFORM OPTICS

Freeform optics is used to illuminate surfaces (screens) with respect to individually specified requirements. The rays of light are redirected to the freeform surface by refraction or reflection, in a way that satisfies the requirements. In doing so, no light is lost and no other optical components are necessary. Consequently, freeform optics is extremely energy efficient and sustainable.

In collaboration with Fraunhofer IPT and Fraunhofer IOF, Fraunhofer ITWM contributes to the strategic business alliance "Design and Production of Freeform Optics (WISA FREIFORM)". ITWM, as lead manager of the alliance, supports the vision of realizing the goal of having a customized freeform surface designed, measured, and manufactured in just 30 minutes for use in medium size enterprises.

Fraunhofer ITWM works with others in WISA FREIFORM on the development and implementation of mathematical algorithms for freeform optics. The software developed at ITWM can be used to calculate the freeform lens and reflector surfaces in just a few seconds. The required light distribution is imported as normal image file (*.bmp, *.png, *.tif, *.jpg). The freeform optics solution is exported as an iges-file and can be read by other software packages.

Both sides of a lens can be designed to achieve a lens with an infinite depth of field. One side is designed so that it realizes the required image, while the design of the other side ensures the image is retained no matter what the distance to the screen.

In 2012, besides working on the design of freeform optics, another research focus was the computation of rotationally symmetric aspheres. The major feature of this kind of freeform lens consists of the fact that light from a point source and falling on the underside of the lens is evenly redirected to an angular domain. In addition to the theoretical concept, new software was developed that enables the rapid computation and storage of this kind of lens as an iges-object. Non-spherical lenses are used, for example, as the primary optics in LEDs (light emitting diodes). These lenses capture all the LED light and redirect it into the required angular domain.

1 *An asphere lens bundles all the light from the half-space into a 20° cone.*

2 *Freeform lenses with infinite depth of field and photos in 1 m or 3 m distance from the lens*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FLOW AND MATERIAL SIMULATION

- MICROSTRUCTURE SIMULATION AND VIRTUAL MATERIAL DESIGN
- HYDRODYNAMICS
- COMPLEX FLUIDS
- MECHANICS OF MATERIALS

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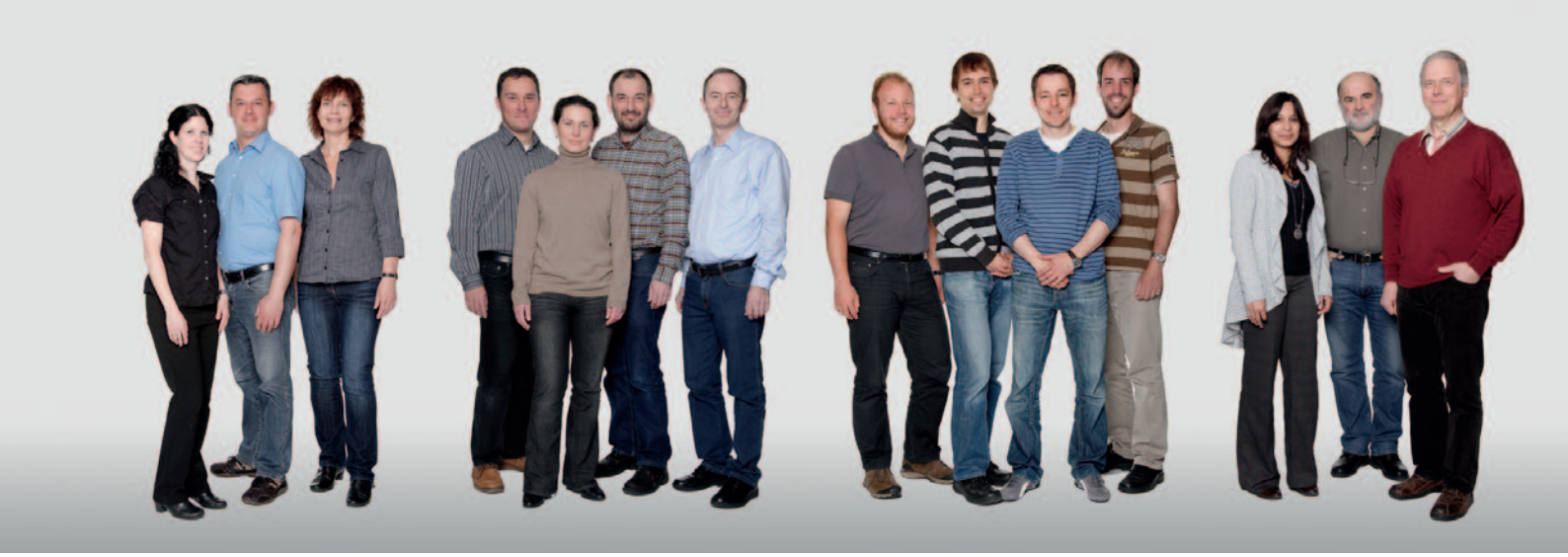
The Flow and Material Simulation department works on multi-scale modeling and development of efficient and robust simulation methods and software tools for the integration of virtual material design in product development process. Modeling and simulation of the production processes of complex composites or hybrid materials are being increasingly integrated in the virtual design process. The typical application areas are the production and functionalization of filter materials and industrial filters, batteries or fuel cells, and fiber or particle reinforced composites. In many applications, an understanding and consideration of the local structural interrelationships among the underlying fluid and material properties is essential for product and process design. The department is uniquely distinguished for its work in the development, supply, and specific application of multi-scale and multi-physical methods and customized software products for industrial operations.

Microstructure simulation and virtual material design

Virtual material design focuses on the development of methods and software for the functional optimization of complex, three dimensional, geometric structures of porous and composite materials. The technology is state of the art, especially, in component design projects for fuel cells, paper making systems, and various kinds of filter media. The marketing and commercialization of the GeoDict software is now the responsibility of spin-off company Math2Market. The cooperation was intensified in many areas during 2012 and a ten-year cooperation and use agreement was signed with Math2Market.

Hydrodynamics

The research and development group focuses on the development platform FiltEST (Filter Element Simulation Toolbox), a customizable decision support tool for use throughout the entire spectrum of filter elements and systems that is attracting global customer interest. Simulation technology is currently also used successfully for non-standard filtration processes, in which flow driven particles are purposefully separated or agglomerated for material production. A follow-on project is continuing the development of the CoPool software for an efficient, three dimensional flow simulation of flooding incidents. This project is now linked as an optional module to the COCOSYS process simulator, where major incidents involving the containment tanks of the Gesellschaft für Reaktorsicherheit (GRS) are analyzed.



Complex Fluids

The consistent formulation and the correct numerical analysis of granular materials in fluids (suspensions) has opened many new possibilities for transitioning to the behaviors of solids. Current industry customer projects involve the simulation of mixers, mills, and solid material filters for various applications. In general, numerical flow simulation with complex material behavior, in addition to modeling, places a high demand on the mathematical solution methods and flexibility of the software. CoRheoS is a development environment for the implementation and combination of specialized solvers for various complex flow processes, which help to create specialized application software for industrial design process. Examples of this are the GRAIN and BEST (Battery and Electrochemistry Simulation Tool) solutions.

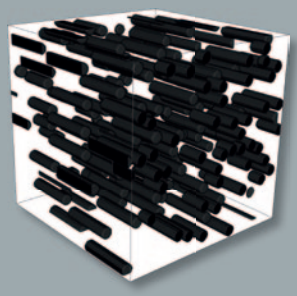
Edward Toroshchin, Tatiana Gornak, Dr. Galina Printsypar, Dr. Matthias Kabel, Dr. Liping Cheng, Sven Linden, Dimitar Iliev, Marco Buck, Johannes Spahn, Tobias Zangmeister, Maxim Taralov, Vassilena Taralova, Dr. Shiquan Zhang, Tigran Nagapetyan

Mechanics of Materials

The simulative micro-mechanical design and the dimensioning of components made of heterogeneous materials are the focus of our current work. Areas of special interest are the thermo-mechanic and acoustic characteristics of lightweight structures made of composite materials. FeelMath is a highly efficient computational process and an easy to use analysis tool for almost any microstructure defined by volume images or analytical descriptions. It is possible to make accurate stress analyses in combination with predicted effective material parameters even for tangible materials. The integration with a fully linked multi-scale analysis of components was also achieved. In the process, the material routine of a finite element software (e. g., ABAQUS) is replaced by a micro-mechanical calculation using FeelMath. Current project work is focused on extending multi-scale calculation in terms of damage and fatigue.

Dr.-Ing. Sarah Staub, Dr. Ralf Kirsch, Christine Roth, Dr. Stefan Rief, Inga Shklyar, Dr. Konrad Steiner, Priv.-Doz. Dr. Heiko Andrae, Dr. Sebastian Schmidt, David Neusius, Dr. Dariusz Niedziela, Dr. Jochen Zausch, Dr. Zahra Lakdawala, Prof. Dr. Oleg Iliev, Dr. Aivars Zemitis

The year 2012 was extremely turbulent because of both planned and unplanned personnel changes. Overall, the group lost ten staff members, although intensive business or scientific contact has been maintained with most of them – in particular, to the spin-off company Math2-Market. In the end, the personnel situation stabilized and the stated business and research objectives could be achieved. The network of international contacts is broadening (especially, via the Interpore Society,) and has lead to the creation of joint research projects like the one with the Center for Numerical Porous Media at the Saudi Arabian King Abdullah University of Science and Technology, KAUST.



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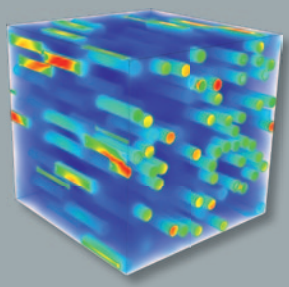

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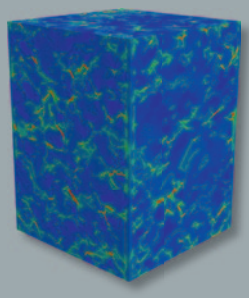


4

FEELMATH VOX

1 *Short glass fibers reinforced plastic*

2 *Von-Mises stress under load in the fiber directiong*

3 *Berea sandstone*

4 *Von-Mises stretching under load in the z-direction*

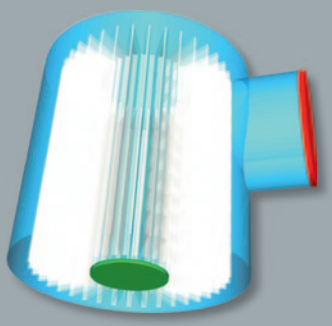
The automotive industry, pursuing the goal to achieve low weights, strives to use composite materials such as glass-fiber reinforced plastics (GRP), and carbon fiber reinforced plastics (CFRP). The GRP and CFRP are very well suited for lightweight construction, but the commitment to use them in mass production is still in its infancy. One essential reason is the inability to precisely simulate crash performance. On the macroscopic level, it is very difficult to extrapolate the mechanical behavior of the material based on its microstructure. Among other things, this has consequences in the crash performance, which is due mostly to micro-cracks. Previously used methods (Finite Element Method) either are connected with high computing time or provide no sufficient accuracy ("mean field" methods).

Within the MEF project (Micromechanical modeling of the crash performance of carbon-fiber reinforced plastics carried out with the Fraunhofer IWM, a numerical method was developed that allows the reliable calculation of the macroscopic mechanical behavior from the complex, heterogeneous fiber structure of the material and can replace complex experiments as a "virtual laboratory".

The approach is based on the fast Fourier transform (FFT) to solve an integral equation and overcomes the barriers of the conventional methods using low memory and shorter processing times. The calculation on realistic three-dimensional microstructure models is accelerated to several orders of magnitude while maintaining accuracy. Thus, overnight simulations are possible on a standard PC and the critical gap in the ability to simulate the crash performance is closed. The developed program, called FeelMathVOX, is integrated among others as a module into the software GeoDict (www.geodict.com) developed at the Fraunhofer ITWM, and commercially distributed by the Math2Market GmbH spin-off.

FeelMathVOX is absolutely robust concerning the complexity of the geometry and the material properties (high material contrast, incompressible materials, and porous inclusions are easily manageable) of the micro-structure. Therefore, it can be applied to the assessment of natural porous materials like rock formations, in addition to the use for optimization of industrial materials and geometries in the aerospace and automotive industry.

FiltEST



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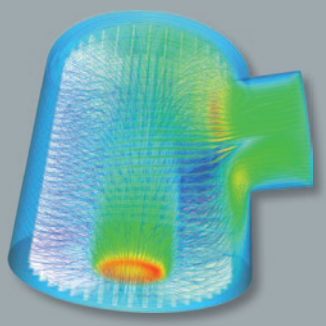

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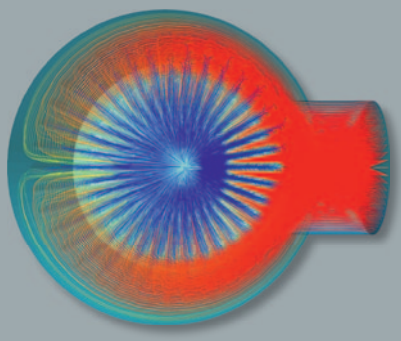


3

FILTEST – FILTER ELEMENT SIMULATION TOOLBOX

Today's filter elements have to be efficient in many ways. The filter efficiency in the literal sense is a measure of the achievable purity of the filtrate. In order to ensure the longest possible operating time, an optimal ratio of dirt holding capacity to pressure drop is required. Last but not least, economical production and ecological sustainability are important criteria when deciding about the product design and the materials involved.

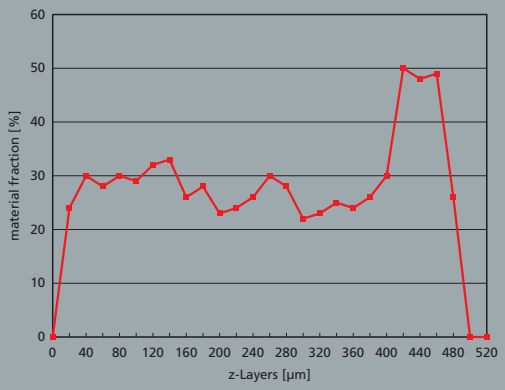
As in other industry sectors, filter element manufacturers are confronted with the need to accelerate their product innovation processes. Reasons for this are steadily increasing performance demands, new or changing fields of application and the rapid development of innovative filtering media, to mention just a few. However, an exclusive use of real-world prototypes for evaluating a filter design is very costly and particularly time-consuming. Specialized simulation software has proven to be an extremely effective means to shorten the developmental period. More than ten years of expertise and experience in filtration modelling and simulation have flown into the Filter Element Simulation Toolbox (FiltEST). The core of this software family consists of the modules to perform the numerical simulation of the fluid flow through the filter housing and medium as well as the particles' transport and their deposition. The obtained knowledge of the velocity field, the pressure distribution, the particle concentrations and deposits allow the assessment of a design's main performance properties without the need for a real-world prototype.

FiltEST allows the user to deal with a large part of the work flow in virtual product design. There are modules for the import of CAD geometries and their conversion into appropriate computational grids. For a variety of filtration models, robust fitting methods are available that can estimate input parameters from experimental data. FiltEST assists the product designers during the post-processing stage, too. Results are written in appropriate file formats for the analysis using spreadsheet and effective visualization, respectively. A graphical user interface facilitates the use of the different FiltEST modules and offers a batch mode to automate the treatment of larger simulation projects. Despite the fact that the generated grids are orientated towards high numerical efficiency, the simulation for more complex geometries still requires substantial computational cost. Popular examples for this are filters with pleated media for which the identification of the optimal pleat count is a major design goal. In order to reduce the number of simulations needed to achieve this, FiltEST offers analytical modules to narrow down the range of corresponding geometrical parameters.

1 *CAD representation of the filter element to be simulated; cylindrical housing with pleated medium, inlet (red) and outlet (green)*

2 *Streamline visualization of the fluid's flow speed (red = high, blue = low) assist with the location of unfavourable flow bottlenecks.*

3 *Streamline visualization of the particles' concentration (red = high, blue = low); using simulation results, ineffective regions of the filter element can be identified.*



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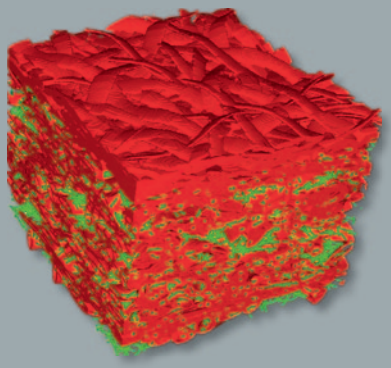

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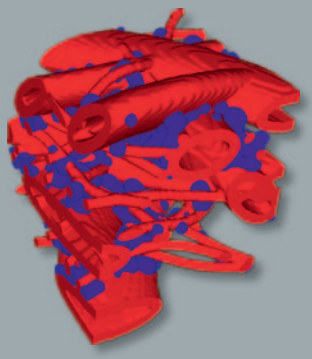


3

PAPERGEO – GENERATING VIRTUAL STRUCTURES FOR PAPER AND PAPERBOARD

1 *Averaged material distribution in direction of thickness*

2 *Two-layer paper model*

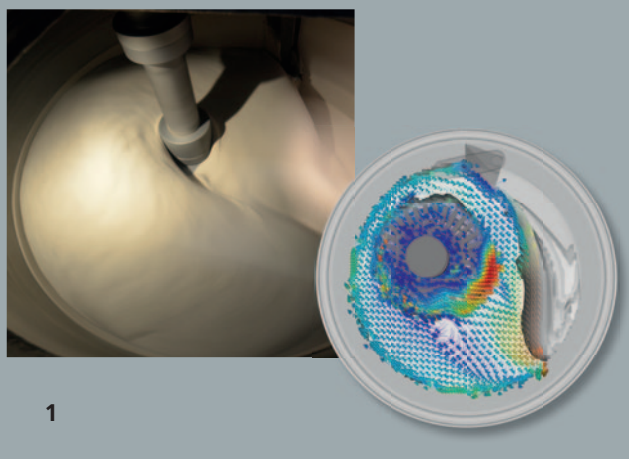
3 *Paper model with filler particles*

Although paper and paperboard seem to be homogeneous in appearance, on a microstructure level they are complex materials, consisting of cellulose fibers, fine fibers, and fillers. Strictly speaking paperboard is also paper, albeit a paper with a grammage of more than 150 g/m^2. The aim is to generate a virtual fiber structure with fillers using a microstructure simulation. Additionally, it should be possible to perform predictions regarding the material properties. The paper industry can develop innovative methods using such predictions, which in turn, lead to optimized manufacturing processes and products.

Fraunhofer ITWM develops the new virtual structure generator PaperGeo, which satisfies the requirements mentioned above and is also a module of the existing software suite GeoDict. PaperGeo enables microstructure models of paper to be generated. Tomography and SEM images provide the basis for the modeling, which facilitates the specification of material distribution, fiber cross-section and orientation, and percentage of filler particles, etc. in the paper. Figure 1 shows the material density distribution of a two-ply paper as found in this analysis. It is evident that the upper layer has a higher percentage of fiber than the lower layer. Using the extracted information, PaperGeo generates a microstructure model that also accounts for the fine fibers (Figure 2). The rough fibers are shown in red and fine fibers are colored green. By using variable parameters, different paper characteristics, for example, permeability can be examined, although we have focused in particular on the influence of potential filler particles. The result is illustrated in Figure 3 with the filler particles shown in blue.

Meanwhile, several well-known companies have selected PaperGeo. Among them are Albany International, Eka Chemicals, Stora Enso, Tetra Pak Packaging Solutions AB, and Fraunhofer Chalmers Centre (FCC). In this case, an interface is developed to allow the extracted effective parameters to be run for the purpose of performing a macro-simulation of edge-wicking (moisture induced edge corrugation).

The software development follows a general approach making it also possible to simulate other fiberous products, like fabrics and nonwovens. Meltblown media are one example.



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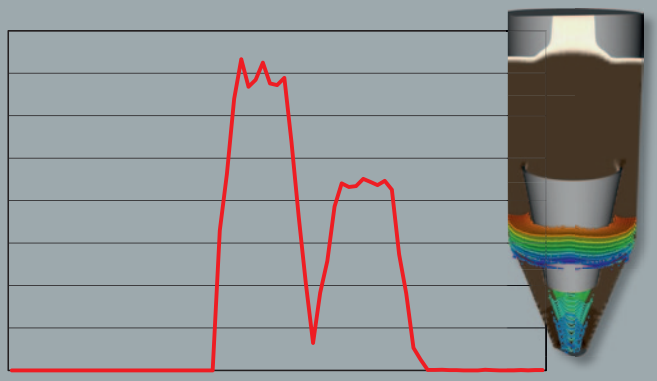

2

GRAIN

DESIGNING GRANULAR PRODUCTS AND PROCESSES WITH GRAIN

Granular materials and the associated processing processes are highly significant to the economy and, at the same time, they are an exciting area of research in the simulation of complex fluids. Approximately 60 % of the products in the chemical industry are granular materials – another 20 % of the products contain powdered forms. For efficient processing, the process behavior plays a key role, that is, the interaction between physical properties. From another perspective, it is precisely these physical properties that place high demands on flow modeling, as well as the numeric algorithms to solve the nonlinear PDEs.

In joint development projects with industry partners, it has been shown that besides the challenges already mentioned, the characterization of the granular materials is an essential component of predictive simulations. Last year we successfully completed the first ZIM project for single-phase characterization of granular materials. An MEF project in cooperation with Fraunhofer IKTS was initiated for two-phase characterization of granular air flows. In the framework of these projects as well as other ongoing projects to simulate air driven granular flows, bead mills, mixers, and silos, the available simulation solvers are being extended to include characterization into the simulation infrastructure. The mid-term goal is a simulation with the characterized materials of our industry partners.

This method is especially useful in the modeling of granular single-phase, multi-phase, and even suspension flows – a new area of modeling – because the characterizations must be performed with regard to the model being solved. In other words, only models with experimentally characterizable parameters are considered. Furthermore, new technologies were developed last year within GRAIN. In particular these involve the utilization of simulation for detailed spatial resolution problems as well as for investigating long term flow patterns. As to the former, local grid refinement in granular flow solvers is now provided, which facilitates more detailed resolution, especially, for example, for the movable parts in mixers or bead mills. Concerning the analysis of long-term flow patterns, it is now possible to simulate, on the basis of previously existing detailed simulation, a time segment with quasi-stationary behavior with tracer particles for a statistically relevant long period. This is possible in fast processes (mixers) as well as for long term discharge experiments with silos.

1 *Design of an experimental mixer comparing experiment and simulation (horizontal velocity profile in the bulk)*

2 *Simulation study of residence times in a silo using tracer particles: Simulated residence time distribution with two characteristic experimentally observed outflow peaks and slice view of intermediate tracer positions.*

IMAGE PROCESSING

- MICROSTRUCTURE ANALYSIS
- SURFACE INSPECTION
- SIGNAL ANALYSIS FOR RAILWAY SYSTEMS
- ULTRASONIC IMAGING

Head of Department
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The worldwide growth of the industrial image processing sector has had a positive effect on the department. We provide visual imaging technology, as well as imaging systems that use X-ray computed tomography and ultrasound devices. In 2012, in close cooperation with our industry and R&D partners, the department developed and implemented customized solutions in the area of image and signal processing as well as ultrasonic imaging. We look back at 2012 as a successful business year with a high share of industry projects. At no time in the past has the department worked on so many projects and installed so many industrial systems. Furthermore, the number of scientific publications, graduate theses, and conference visits was never greater.

Surface inspection

Surface inspection in industrial production, i.e., the control of the optical appearance of a product, is one of the most important measures in quality assurance. Inspection systems identify not only the functional faults, but also, to an increasing degree the aesthetic "faults". The detection of such faults is challenging, due to the difficulty of translating subjective fault descriptions into mathematical models. The department has had a primary focus, especially in recent years, on such surface inspection systems with highly complex algorithms and was especially rewarded this year – in no other year have we installed so many surface inspection systems.

Analysis and modeling of micro- and nanostructures

Today's materials have microstructures that to a large extent determine their macroscopic properties. The department develops algorithms for the characterization and stochastic modeling of such microstructures using 3D image data. Our products are dedicated to a deeper understanding of spatial geometry and the relationship to the structural properties in the materials and present new possibilities (e.g., the optimization of material properties) through virtual material design. In 2012, other areas of study were the analysis of the structural features of ceramic foams that define the filter characteristics as well as the modeling of fiber and cellular structures from SEM images.

Ultrasonic imaging

The Ultrasonic Imaging group investigates another imaging technology and presents new opportunities for the inspection and visualization of materials and components of interest to industry. The aim is to determine and evaluate material properties, prepare simulations and optimize ultrasonic sensors, develop fault recognition and classification systems for complex

components, determine probability of detection (POD), as well as the optimization of inspection processes. Another focus of the group last year was the development of innovative software linking traditional optical inspection technology.

Signal analysis in railway systems

In an enduring, 20-year cooperation with Progress Rail Inspection and Information Systems, Fraunhofer ITWM develops and improves software for early identification of overheated axle bearings and blocked brakes on passenger and freight trains. This is achieved by capturing temperature data using infrared sensors and subsequently, a sophisticated conversion and assessment process. Recently, a redesign of the software and hardware was completed so that a new product was brought to market in 2012.

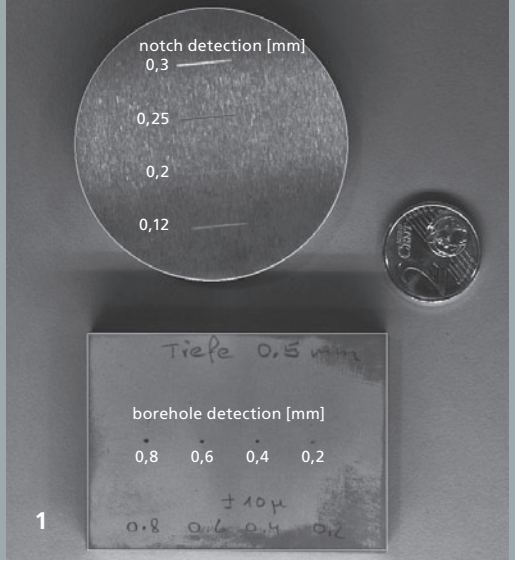
Software packages

Fraunhofer ITWM licenses two image processing software packages – MAVI and ToolIP – for commercial use as well as for training and educational purposes. These two products were brought closer together in 2012 so that ToolIP can now be used in conjunction with MAVI and the MAVI algorithms can be used directly in ToolIP. MAVI is a software system for the analysis of volume images of complex microstructures, for example, open and closed cell foams or fiber reinforced composite materials. MAVI has a modular design that enable it to be used for three-dimensional images of other structures as well, like snow or lichens. MAVI has a core of functions that enable the characterization of complex geometries of microstructures. Volume, surface, integral of mean curvature, and the Euler number are determined for the whole structure or for individual objects. MAVI supplies local analysis methods, for example, for local porosity, thickness, or orientation. Spatial fiber orientation tensors can be specified for fiber reinforced polymers. In addition to MAVI, we developed a particle analysis software called MAVIparticle.

ToolIP is a software programming tool that enables intuitive graphic programming of complex image processing algorithms. The underlying image processing library contains approximately 300 different algorithms for image enhancement, edge detection, object recognition, registration, segmentation, feature calculations, and classification, and also for matrix operations, basic operations and image transformations. The image source is of secondary importance, i. e., images from the visible spectrum as well as X-ray, ultrasound, infrared, or other image data can be processed.

Martin Braun, Michael Arnold, André Liebscher, Priv.-Doz. Dr. Martin Spies, Tony Valier-Brasier, Alexander Dillhöfer, Hans Rieder, Kai Taeubner, Christine Roth, Sebastian Hubel, Henrike Stephani, Andreas Fink, Björn Wagner, Behrang Shafei, Dr.-Ing. Janis Keuper, Dr.-Ing. Christoph Fünfzig, Thomas Redenbach

Torben Prill, Thomas Weibel, Dr. Katja Schladitz, Rebekka Malten, Dr. Ali Moghiseh, Dr. Oliver Wirjadi, Franz Schreiber, Dr. Ronald Rösch, Markus Rauhut, Dascha Dobrovolskij, Irene Vecchio, Andreas Jablonski, Dr. Julie Escoda, Erwin Kraft, Michael Godehardt, Mark Maasland



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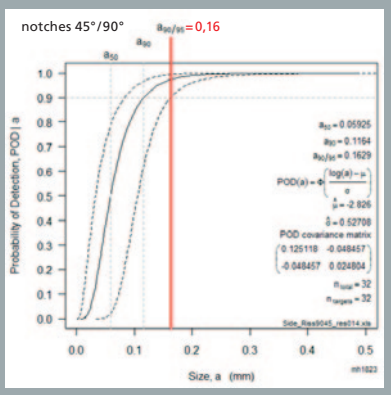


2

POD ANALYSIS IN ULTRASONIC IMAGING AND IMAGE PROCESSING

1 *Test piece*

2+3 *The POD curve shows under optimal illumination (left plot), POD increases (from 0.16 mm to 0.12 mm). This graphic shows POD is an appropriate tool for evaluating a lighting concept. (Parameter: Side lighting, resolution = 0.14 mm)*

4+5 *This figure illustrates that by using a better algorithm (variant 2, right plot), POD also increase (from 0.21 mm to 0.19 mm). In this way, POD be used to help evaluate image processing methods. (Parameter: Notches, resolution = 0.12 mm)*

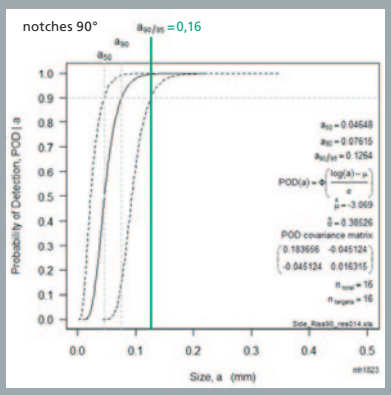
The Probability of Detection (POD) concept represents an important complementary tool for inspecting and evaluating the integrity of a component. The POD determines the probability of finding a defect in the component. This is shown as a function of defect size **a**. The resulting POD curve, together with the defined confidence intervals, provides the defect size that can be detected with reasonable probability. The resulting defect size is then compared to the given requirements for the components integrity. The principle POD curve shows that the probability of detection increases as the defect size increases. At size $\mathbf{a}_{90/95}$ the lower 90 % confidence limit crosses the 90 % POD level. This is usually accepted as the defect size that is certain to be detected.

Over the past few years, POD analysis has become well established, especially, in the area of X-ray and ultrasound analysis, so that meanwhile, customers are requesting the inspection systems to provide a certain POD. In image processing, however, POD analysis is relatively unknown. While the measurement of response signal **â** can be performed for a reasonable cost using ultrasonic methods, it is much more complex to do this in image processing. In this case, a metric must be developed for the response signal **â** for each type of defect. Whether or not a system is applicable in practice is decided mainly by the degree to which the end-user defined rate of detection and detection probability is achieved, in particular, for surface inspection systems. Typically, these parameters are empirically determined in the form of a preliminary study, i. e., models are used to decide whether the customer requirements are feasible.

POD analysis is clearly a key tool for generating quantitative statements like, for example, "This inspection system is guaranteed to detect defects of a size of 0.1 mm." Current research focuses on POD modeling as well as its use in image processing systems.

The modeling of POD

The internationally accepted POD analysis procedure is defined in US Department of Defense publication MIL-HDBK-1823. This reference is based on the assumption of a standard normal distribution of the measured values. Other assumptions are made for a linear dependence of the response signal and the defect size, and a constant spread/variance of the measured values. These assumptions, however, do not always reflect the reality. This is the reason why we have expanded POD analysis in two promising models. They account for a normal distribution of measured values of various spreads/variances as well as for a non-linear dependence of amplitude versus defect size. On the basis of examples from the field of visual surface inspection



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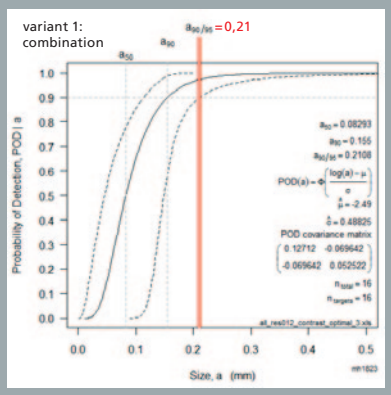

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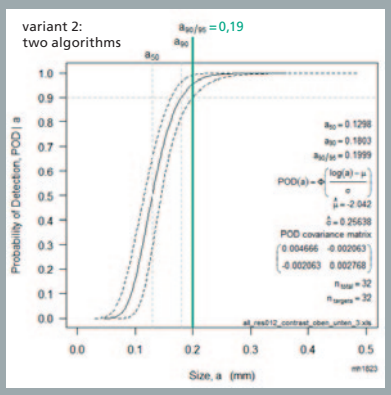

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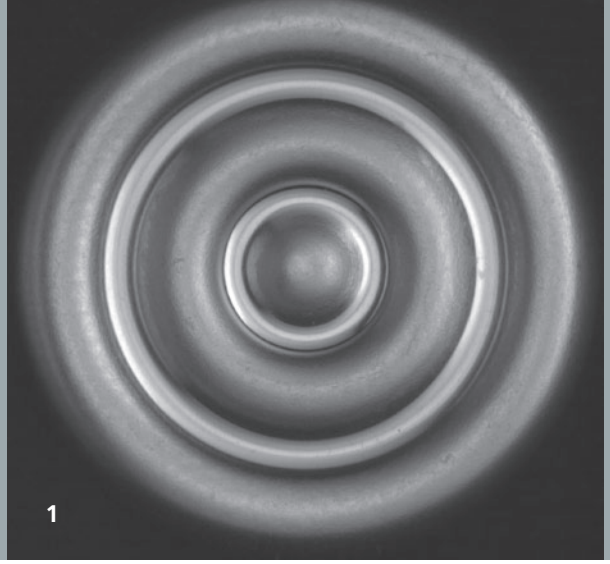
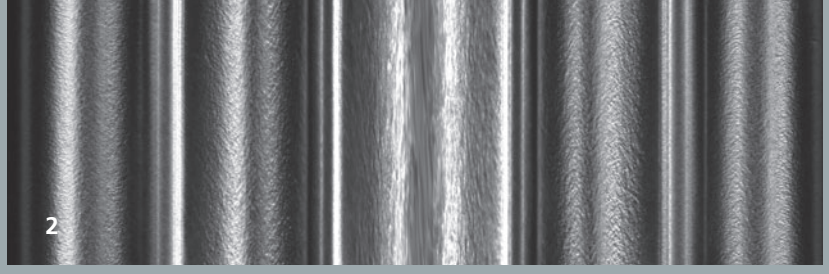
and ultrasonic inspection of hard to test materials, we are studying among other things the effect of extending the model to the characteristic POD sensitivity $\mathbf{a}_{90/95}$. Additional studies focus on the relationships between the defect detection threshold, resulting POD curve, and the probability of false indication.

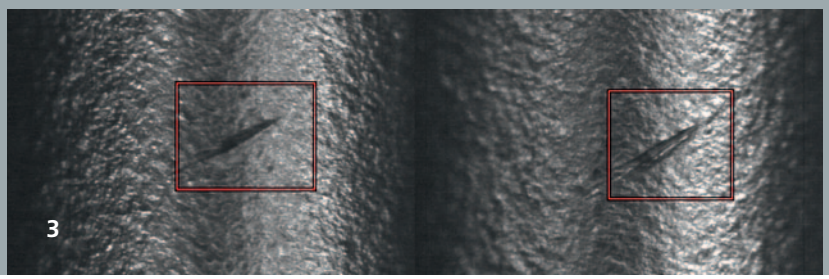
The use of POD in Image Processing

The application of POD analysis in image processing demands the development of appropriate metrics for the relevant type of defect (crack, hole, etc.). We have developed simple to calculate metrics that already in preliminary studies, allow us to make quantitative statement regarding the probability of detection. The metrics ideally are independent of the algorithms used, but nevertheless still take the attributes of typical analysis methods into account. We have demonstrated that POD analysis is a valuable tool for quantitative evaluations and comparisons of recording setups and algorithms in image processing. However, for more complex defects, we found the metric is dependent on the algorithms used. We performed an $\hat{\mathbf{a}}$ versus $\mathbf{a}$ analysis to determine the probability of fault detection on test bodies with holes and channels of various dimensioning and orientation in order to make quantitative assessments of various existing inspection systems and, by means of the POD analysis, various algorithms were also evaluated.

As a research topic, POD analysis in the area of ultrasound imaging and surface inspection is in strong demand and we provide it as a service for our customers in industry.







SURFACE INSPECTION OF VEHICLE BRAKE SYSTEM COMPONENTS

1 *Original view of brake shoe*

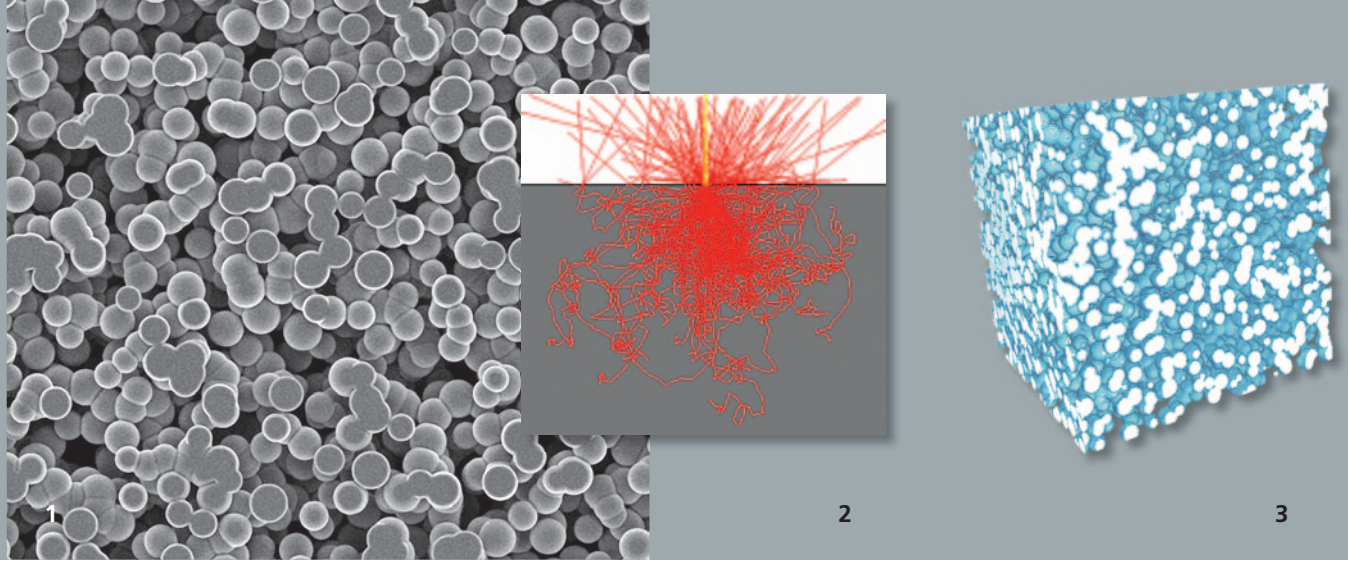
2 *Processed images with high resolution line camera*

3 *Examples of impact points*

The quality requirements for the mass produced components for the automobile industry are constantly increasing. This is certainly true for the manufacturing of deep drawn (thermo-formed) components that exhibit especially difficult surface properties. In cooperation with partners Continental and Hubert Stüken, a specialist for deep drawing technology, ITWM has succeeded in developing a robust, highly accurate inspection system for brake shoes, which is suitable for use in demanding industrial applications.

Brake shoes are built into the damping chambers of car brake systems and, as a safety related application, are subject to special quality assurance inspections. As a result of the production methods, surface defects or special points of impact may form on the still untempered components. The automatic detection of these defects is necessary to warranty the tightness of the components when installed. A maximal inspection time of three seconds per component is required. The brake shoes typically consist of two pieces of steel, an inner and an outer, welded together. Impact points of a length of 0.3 mm must be detected in specified areas of both sides. The advanced freeform nature and the complexity of the brake shoe geometry posed a unique challenge for automated inspection systems. Another challenge is presented by the very high optical resolution required. Consequently, the depth of focus is greatly reduced, while at the same time, any roughness in the surface of the base material comes to the foreground. A compromise had to be found between the required resolution and the depth of focus.

The inspection system consists of three, high resolution (4096 pixel) monochrome line scan camera stations, each with high power LED ring lighting. The use of line scan cameras enables the complete diameter of the brake shoes to be imaged. Images of impact points are taken in the direction of the lateral exposure as well as away from it in one rotation. In this way, even impact points with edges that are flattened on one side, or are not very pronounced, are still detected. The brake shoe evaluation is accomplished objectively and the inspection results are documented. The system, which enables 100 % control, is easily operated by trained operators without any special knowledge of image processing. This ensures that no NOK parts will be further processed, which if processed could result in later complaints. Complex, sophisticated, parallelized algorithms make it possible to quickly and reliably identify defective components early in the production process, which consequently leads to significant time and cost savings.



SIMULATION OF SEM TOMOGRAPHS AND SEM IMAGES OF HIGHLY POROUS MICROSTRUCTURES

The development of new materials and optimization of well-known materials require an in depth understanding of the interrelationships between micro-structure and material properties. Traditional characterization on the basis of images from light microscopy is not a sufficient method for very complex, fine, or porous microstructures. The scanning electron microscope (SEM) achieves high resolution and conveys good spatial features. FIB tomography – the successive removal of layers of the structure using a focused ion beam (FIB) and SEM images of the slices – serves as a means of analyzing 3D structures at a resolution of 10 nm. However, for the purpose of analyzing highly porous structures, SEM and FIB-SEM images are generally ruled out because SEM images show a projection of a layer of unknown thickness. Furthermore, the sample is tilted against the SEM beam path in FIB tomography, which sometimes causes deeper areas to appear lighter than the actual foreground structure. This "shining through" effect hinders the automatic segmentation of the solid components in the image required for a structural analysis and numerical simulation of the material properties in 3D images.

Manual segmentation for SEM tomography of several hundred SEM images is simply not the answer because of the enormous effort it requires. A significant contribution to a solution is provided by simulating the imaging process, because the correct segmentation result is known for the images that are generated. Imaging artifacts appear in SEM images mainly because of the diffusion of the electrons passing through the sample. This electron transport can be simulated especially well by a Monte-Carlo methode. Each random path generated represents an electron beam that enters the sample and gets diffused by the atoms or molecules in the material. MONSEL-II simulates the quantum physics effects. Because the simulation of a SEM tomograph of a realistic size (500^3 – 1000^3 pixels requires billions of trajectories to be followed for a sample of approximately 10,000 primary grains, the costs exceed every practical boundary. At ITWM acceleration methods have been developed and combined with established methods so that a SEM tomograph can now be simulated in just a few minutes.

The simulation also lead to the development of a segmentation method that has been used successfully in FIB tomography of micro-porous layers of fuel cell. The verification using simulated data shows this algorithm is currently the best available.

1 *Simulated secondary electron image of a Boolean model of 25,835 overlapping spheres. The simulation used 10,000 electrons per pixel. (Parameter: 5 kV acceleration voltage, 50 nm spotsize)*

2 *100 simulated electron paths*

3 *Volume rendering of the Boolean model in figure 1*

SYSTEM ANALYSIS, PROGNOSIS AND CONTROL

- SYSTEM ANALYSIS AND CONTROL
- DATA MINING AND DECISION SUPPORT
- MULTISCALE STRUCTURE MECHANICS

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Drawing from its resources in the areas of mathematical systems and control theory, data mining, and multivariate statistics in addition to multi-scale analytical methods, the department concentrates within its three core areas on the modeling, analysis, prognosis, and control (monitoring) of complex system behaviors.

System analysis and control

The development of a model-based prognosis system and control strategies as well as the related hardware integration are typical tasks in many applications. Control design includes, besides the particle filter method developed by the group, other concepts like robust control strategies, learning iterative control approaches, predictive control model and neural control. Appropriate model and dimension reduction methods present important components for dealing with the complexity of the underlying model. Besides standard techniques, the group has special expertise in the area of symbolic model reduction, in particular, for system analysis of heterogeneous networks, for example, energy distribution grids.

Data mining and decision support

Mathematical methods and a descriptive visualization of complex data can support decision making in many situations. Multivariate statistical methods, time series analysis, data mining, fuzzy logic, and graphic exploration techniques are used. Models based on measurement and simulation data methods are used for the prognosis, classification, and simulation of product and material properties. An enhanced system understanding can then be generated using appropriate analytical methods.

Multiscale structure mechanics

In this area of research, methods are developed for the numeric computation of microscopic stress-strain behavior and the effective material properties of industrial textiles or composite materials. We apply homogenization methods which allow for the computation of average (effective) elastic, viscoelastic, and plastic material properties, accounting for microstructures and the different constitutive laws. The computation of effective free temperature deformation, swelling, and shrinkage is also possible. Furthermore, contact problems with micro-rough surfaces are solved with homogenization methods. In addition, we study time-dependent processes for composite bodies where the macro strength and durability are examined with respect to fatigue, creep strain, impact load, and wear.

Together, we supply consulting services as well as customized software development and internal products in the application areas energy systems, electronics/mechatronics, biology and medicine, material and product design in addition to production and business processes. Typical topics in the area of Energy Systems are condition monitoring and monitoring of power turbine generators, modeling, analysis, and stabilization of energy grids as well as increasing the energy efficiency in industrial production processes.

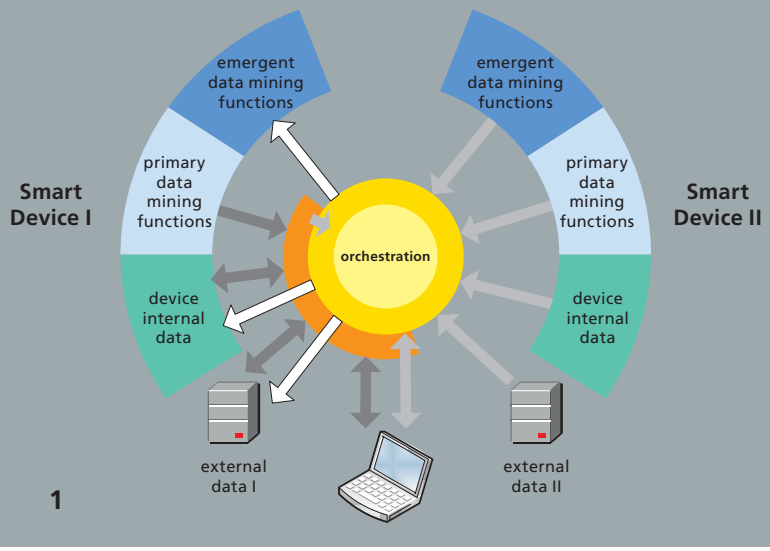
The complexity and sensitivity of the system behavior of many electronic and mechatronic applications significantly increases with the growing integration density towards nanoscale chip technology and the connection of diverse sensors and actuators. In this environment, systems theory models are proposed for both mechanical and electronic components as well as linked mechatronic systems in order to analyze or verify system behavior through simulations (software/hardware in the loop). Advances in the Life Sciences especially in the definition of suitable omics data are bringing the vision of personalized medicine, on the basis of appropriate biomarkers, one step closer to reality. The group contributes in many ways: Mathematical modeling combined with simulation and optimization tools improves biotechnological processes and supports the development of highly effective and specific medications; powerful data analysis tools support diagnosis and decision making; interactive software facilitates the conduct and processing of individual patient consultations.

Applications in the area of Material and Product Design are concerned with the development of models for forecasting, classification and simulation of product and material behaviors based on measurement data and simulated data. These models facilitate decision making regarding a material or the product design. The "Design of Experiment" data collection technique plays a key role in keeping the number of costly experiments to a minimum.

Production, assembly and business processes are differentiated by a high degree of complexity resulting from the linkage and interaction of many components. The systematic analysis of these processes using modern, model-based systems theory or data mining methods, with abundant but often unused data, holds the promise of great potential. To mention only a few, there is process optimization with respect to quality or energy efficiency, detection of weak points, and systematic design of new products.

Dr. Anna Shumilina, Dr. Jan Hauth, Andreas Barthlen, Achim Faßbender, Dr. Alex Sarishvili, Dr. Hagen Knaf, Hans Trinkaus, Matthias Hauser, Mohammed Ali Khozoei, Carmelo Vicari

Dr. Dominik Stahl, Dr. Christian Salzig, Dr. Alexander Dreyer, Thanh Hung Nguyen, Tjorben Groß, Dr. Patrick Lang, Dr. Andreas Wirsen, Vladimir Shiryaev, Dr. Julia Orlik, Daniel Zoufine Bare Contreras



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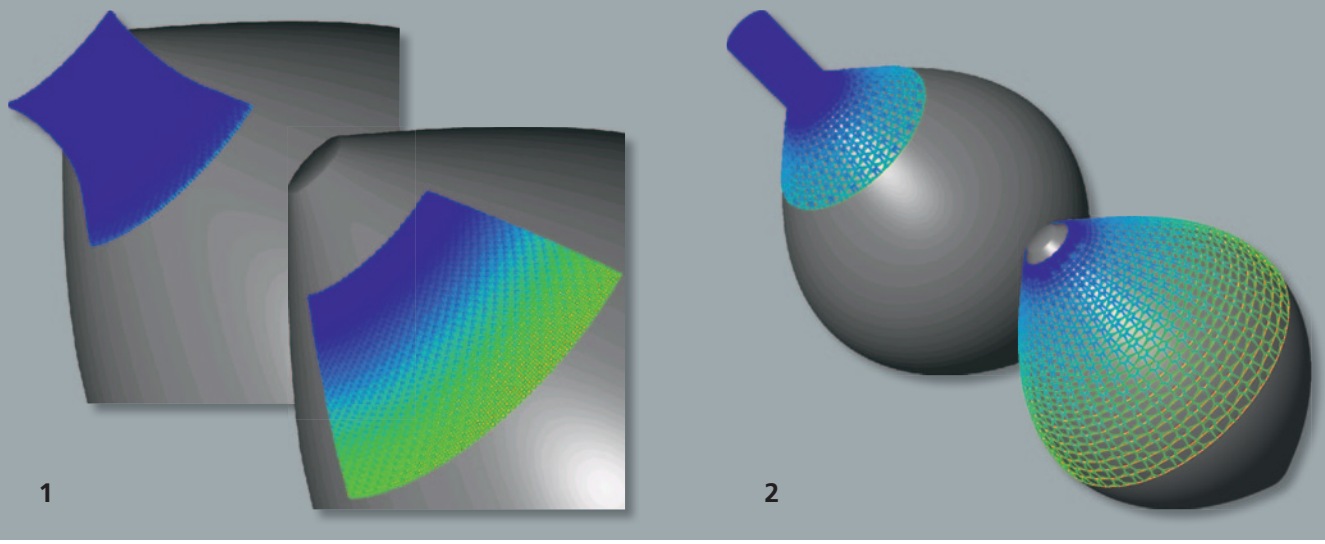
EMERGENT – THE FOUNDATION OF EMERGENT SOFTWARE

1 *Interaction of two smart devices via an orchestration component*

The study of the prerequisites for a new category of business software – emergent software – is the topic of the BMBF sponsored project "Emergent".

"Emergence is the way complex systems and patterns arise out of a multiplicity of relatively simple interactions. In the process, the emergent characteristics of the system are not traceable directly back to the characteristics presented by the individual elements." (Wikipedia). In the context of business software, emergent software dynamically and flexibly combines a number of different devices from different manufacturers, in order to support the highly complex requirements of the digital enterprise. Emergent software dynamically adapts to the requirements of the market and business environment, supports complex and dynamic enterprise networks, and enables innovative services and markets on the internet of the future. Such services can be easily combined and business processes can be more quickly and flexibly implemented. Furthermore, through the combination of powerful methods, the software can extend the functionality of the service.

The group contributes to "Emergent", in collaboration with DFKI (SmartFactory) and the Mineway company, by developing concepts for so called "smart devices". This refers to integrated devices with a data mining component that support the device function, such as a precision pump with a built-in component for predicting future delivery accuracy. This can be used for scheduling timely maintenance or the replacement of the pump. The smart devices built into a system can exchange data or programs via an orchestration component, creating new emergent data mining functionalities through the combination of software components. If one of the feed pumps mentioned above, for example, has a component for classifying data, in combination with available data on the delivery accuracies of pumps made by various suppliers, it can be used to produce a comparison of manufacturers – even if this was not the original purpose: The orchestration component "identifies" such possibilities by means of feed pump meta data and suggests them to the user. Emergent software to function conveniently must become much more transparent to the user. This is why a follow-on project involves the study of graphic-based methods for defining specific process parameters. As a partner in the Emergent project, ITWM contributes within the framework of the Leading Edge Software Cluster initiative "Software Innovation for the Digital Enterprise" (www.software-cluster.com).



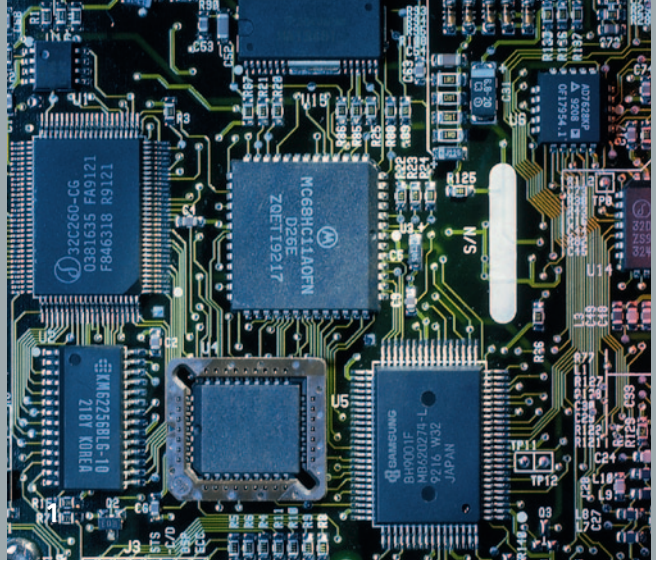
MODELING AND SIMULATION OF FIBER STRUCTURES AND INDUSTRIAL TEXTILES

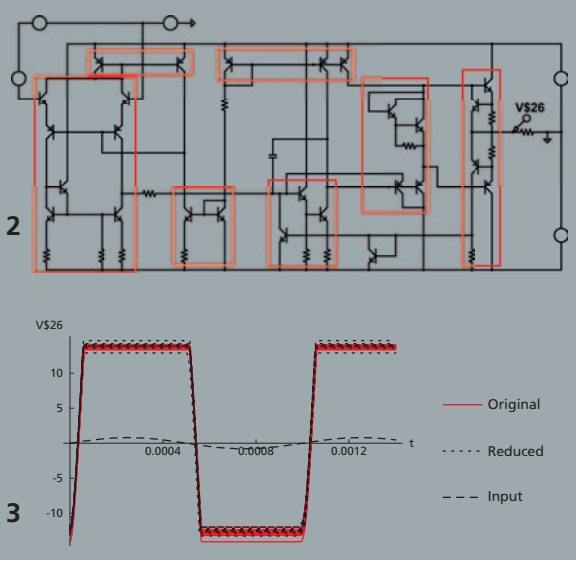
Multiscale modeling and simulation of woven and knitted fabrics with a special focus on the contact between individual threads or fibers, including 3D-knitwear and fiber materials with heterogeneous microstructure, is the topic of this research area. The value adding development of a textile with optimal properties is also included in the studies. The contact leads to a nonlinearity of the problem and direct numerical simulation is very expensive. Therefore, a multiscale computational approach that permits a reduction of the problem dimension is used for effective calculations. The problem has two small parameters: The first is the relationship between periodicity or representative fabric element and the dimensions of the whole fabric. The second represents the relationship between fiber or yarn diameter and length. Mathematical asymptotic methods of homogenization and dimensional reduction are applied. The aim of homogenization is scale separation, so that the effective material behavior for the whole fabric can be derived from uni-directional experiments on a periodicity or representative elementary cell structure. The dimension reduction modifies the fabric to an FE beam mesh, where the total deformation is computed as a superposition of tension, bending and torsion of one dimensional beams. In the process, the mechanical contact between the beams is explicitly taken into account.

1 *Simulation of putting on a compression sleeve*

2 *Evolution of one-sided contact fabric with fully resolved microstructure*

In considering the contact, both asymptotic approaches require an innovation that requires a new analysis, which is the subject of the DFG Project "Modeling and Simulation of Fiber Structures and Industrial Textiles", underway in collaboration with the department of mechanical engineering at the University of Erlangen. The results have been published in separate mathematical and mechanical journals. In the first paper, an effective elasto-plastic material behavior is derived for textiles under consideration of contact, while further papers derive the contact conditions for beams from the known three-dimensional frictional forces and fiber cross section data. Corresponding computational algorithms were implemented and are based on the beam Finete Element method, extended to the contact. In addition to calculating the effective mechanical material properties for a variety of existing woven and knitted fabrics in industrial and life science applications, the approach also has the potential for the optimal design of innovative textiles having a prescribed mechanical properties profile. Furthermore, the developed approach for textiles can simulate and analyze different surface treatments. In this way, it is possible to determine in advance the quality of the resulting fabric surface in order to prevent the formation of wrinkles and other visual inhomogeneous features.





MODEL REDUCTION FOR A RAPID SIMULATION OF NEW SEMICONDUCTOR STRUCTURES

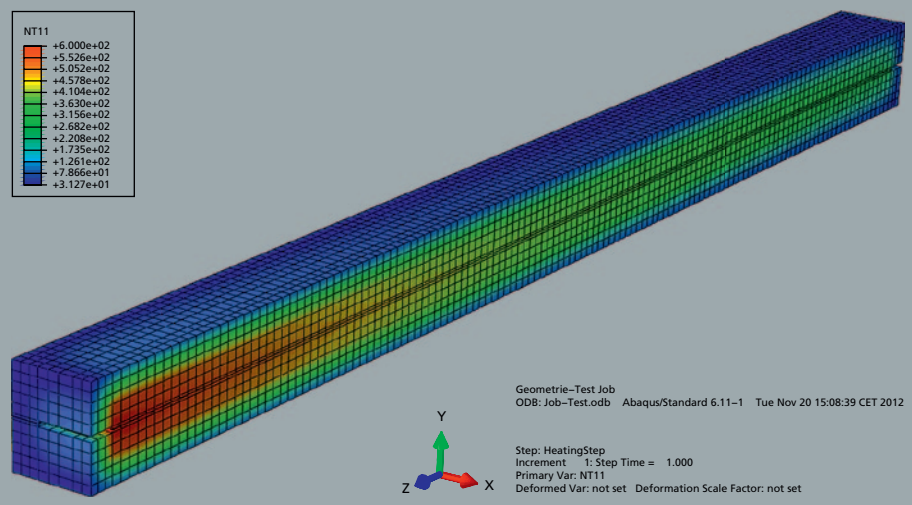
1 Hierarchically structured circuit

2+3 Schematic of the OP741 Operation Amplifier, which consists of 7 subcircuits and the result of a Monte-Carlo simulation at the output of the original and the reduced system.

The traditional modeling of analog circuits by means of nominal systems cannot keep pace with the transition from micro- to nano- electronics. The relative increase in process fluctuations in the production and operation of semiconductor devices results in a growing number of circuits with a system behavior outside the defined specifications. To combat this trend, it is necessary to design more robust circuits. Under the BMBF project "MoreSim4Nano", ITWM supports the development of robust circuits by means of generating reduced nonlinear behavior models of analog circuits under variable parameters and, in this way, helps to minimize production of faulty products. We work with the aid of industrial circuits and chip manufacturer X-FAB to verify the method models developed.

The challenge in creating such reduced behavior models is the constantly growing size of modern circuits. The simulation and model order reduction (MOR) of such circuits requires immense computing resources. Thus we are expanding the concepts of hierarchical MOR on systems with parameter variations developed in BMBF project "SyreNe". This includes the use of hierarchical structured circuits to perform an accelerated MOR. Existing algorithms used for the MOR of systems with parameter fluctuations as developed in the "HIESPANA" project, are applied on the separate subsystems in a manner that allows the recombination of the resulting reduced subsystems to a reduced overall system. This method eliminates the need to model large-scale systems, which next to parallelization of this new approach, is critical for the acceleration of the MOR processes. Another advantage is the possibility of selecting and using different reduction methods, so that the best possible reduction is achieved for each subsystem.

However, in the beginning it is unclear what effect the reduction of individual subsystems will have on the error of a nonlinear integrated system. To solve this problem, we developed a heuristic and adaptive, sensitivity-based method for error control. As an example of a system with parameter tolerances, we chose the OP741 operational amplifier, which is designed to amplify an input sinus signal of 1 kHz to ±14 V. Tolerances are applied for the dimensioning of transistors and resistors. The hierarchical MOR, after nearly five hours, provides an approximately 70 % reduced system with 87 nonlinear equations that still contain the physical parameters of the circuit. The new method proved to be 2.5 times faster than the non-hierarchical methods with the same error limit.



1 *Abaqus model of a lehr*

INNOVATIVE CONTROLLER DESIGN FOR AN ENERGY EFFICIENT ANNEALING LEHR

Energy savings in the glass manufacturing process is the goal of the Schott AG as it seeks the development of new concepts for the lehr and annealing furnaces. The aim is to modify the crucial subsystems of this plant such as heating and temperature tracking by implementing innovative software that promises a significant increase in profitability and energy efficiency. In the BMWI project "Development of an energy efficient furnace concept for the thermal treatment of glass", Fraunhofer ITWM is performing a contract for the Schott AG that involves model-based controls to minimize the energy input to a lehr by means of innovative actuators.

The goal of modeling is to reproduce as accurately as possible the actual lehr, including actuators and temperature sensors under dynamic conditions. By means of a simulation of this reference model, the control concept can be verified – and thus, the number of experimental test setups required is greatly reduced. Additionally, a model of lesser complexity is required as the basis for a model-based real-time capable controller. Initially building from the reference model, we then generate a simplified, linear, but nevertheless high dimensional surrogate model that represents the lehr in its various operating points. To generate the necessary real-time capability for the controller, the model of the lehr is decomposed into segments, a model order reduction is performed at the segment level and the reduced model then reassembled into the integrated furnace model. This procedure yields a reduction of the model dimension by a factor of 20 with a target temperature deviation of 100 μK in the glass.

In order to achieve a high quality glass, an exact tracking of the glass temperature throughout the entire cycle in the lehr must be maintained, i. e., the glass temperature in the lehr must be set by means of actuators, to a predefined temperature curve for the entire length of the lehr. Initially, the actuators developed by the Schott AG were analyzed in terms of their suitability as temperature controllers and, expanding on this, new algorithms were developed to determine the optimal sensor positions inside the lehr. In control design, it is important to consider the dynamics of the temperature gradient processes from end to end in the lehr, the long cycle time of the glass through the furnace, and the actuator interactions as well as any physical restrictions. A predictive model was selected for the controllers, which besides the reaction times, also takes physical constraints into account and has already proven itself in industrial application. The problem of optimization was solved by modern innovative optimization strategies developed utilizing the temperature dynamic in the cooling oven.

OPTIMIZATION

- OPTIMIZATION OF ENTERPRISE STRUCTURES AND PROCESSES
- MEDICAL THERAPY PLANNING
- OPTIMIZATION IN VIRTUAL ENGINEERING

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The main objective of the department is to work in close cooperation with partners in research and industry to develop custom solutions for planning and decision making problems encountered in the logistic, engineering and life sciences. The work is characterized by a methodical approach to the task at hand while tightly integrating simulation, optimization, and decision support. Simulation in this context refers to the construction of mathematical models while taking into account the design parameters, restrictions, and optimizing the quality and costs. The department's core competencies include the development and implementation of application and customer-specific methods of optimization to calculate the best possible solutions for the design of processes and products. A distinguishing feature is the close integration of simulation and optimization algorithms that take multiple criteria approaches into special consideration in the development and implementation of interactive decision support tools. Optimization is understood less as a mathematical problem to be solved, but rather more as an ongoing process, supported by the division through the use of appropriate tools.

Optimization of enterprise structures and processes

The portfolio includes consulting and support for the modeling of logistical and organizational planning systems and the development of customized software components. Using the optimization methods in our own software tools, proposed decision support solutions are generated for the best compromise between the competing planning goals "minimizing costs" versus "maximizing quality of service". Based on discrete event simulation and combinatorial optimization, this research focus is concerned with efficient strategies for transport logistics, with layouts, with planning and control of production and R&D processes, with planning models and algorithms for the disposition of process activities in hospitals and the health care sector, and with mathematical modeling of planning tasks in public transportation systems.

Optimization of medical therapy planning

The trade-off between the prospect of a cure for a serious illness and the prevention of side effects routinely poses a difficult planning challenge to doctors in therapy planning. The research focus of therapy planning is the development of new methods for planning clinical therapies on the basis of multiple criteria optimization. In collaboration with Massachusetts General Hospital (the teaching hospital of Harvard Medical School), German Cancer Research Center, Fraunhofer MEVIS, and commercial partner Siemens Health Oncology Care Systems, the group is developing innovative planning components for the ionizing radiation therapy, ultra sound therapy, and radio frequency ablation, which in a surprisingly simple manner, enables medical physicists and

attending physicians to weigh the options between chances and risks of treatment. An ongoing project with the Kliniken Essen-Mitte (KEM) is developing an assistance system for decision support and quality assurance for senology chemotherapy.

Optimization in virtual engineering

The use of mathematical optimization methods in the engineering disciplines relies on modeling physical relationships and technical processes and mapping them in computer programs (Virtual Engineering). Optimization assists engineers in the design of products and processes to ensure quality and cost targets are satisfied to the maximum extent possible. Currently, there are projects in the area of gemstone polishing, the design of chemical processes, the optimization of spray paints drying processes, the optimal planning of photovoltaic power plants, and the best possible design of mechanical inspection stations for vehicle parts. In the process, software components for simulation-aided optimization are produced, which can solve highly dimensional problems using specially developed integration techniques derived from simulation and optimization algorithms. A simulation surrogate identifies interesting parameter ranges, before the detailed optimization is performed in the full simulation. This hierarchical approach facilitates the study of sizable portion of the decision-making horizon and saves time.

The year 2012 can be characterized as a great economic success for the division. Here are a few of the highlights: the follow on agreement to develop the software SIEMENS PV Planet for the layout of photovoltaic power plants, the further development of the software ChassisPack for the engineering of truck chassis assemblies for Volvo GTS in Göteborg, the development of a multi-criteria planning platform for production engineering processes in the chemical sector for BASF, as well as the contract from the Essen Mitte Clinic for a decision support platform for chemo therapy planning for breast cancer patients. In the area of professional scientific research, in addition to the awarding of three successful PhD degrees, we must highlight the approvals from the BMBF and BMWi for the projects MasterCraft, SINDIUM, and NanoPur, the funding recommendations by BMBF and BMWi for the draft proposals ViLoMa, SPARTA, and SkaSIM, and the formal collaboration with the Laboratory of Engineering Thermodynamics of the TU Kaiserslautern for the modeling, simulation, and optimization of production engineering processes.

Dr. Heiner Ackermann, Dr. Martin Berger, Dr. Richard Welke, Dr. Sebastian Velten, Tabea Grebe, Dr. Philipp Süss, Chhitiz Buchasia, Dimitri Nowak, Alexander Belyaev, Dr. Kai Plociennik, Dr. Ingmar Schüle, Dr. Uwe Nowak, Dr. Hendrik Ewe Dr. Jonas Haehnle, Dr. Veronika Dick, Dr. Maksym Berezhnyi

Bastian Bludau, Dr. Neele Leithäuser, Dr. Peter Klein, Dr. Jan Schwientek, Katrin Stöbener, Dr. Volker Maag, Andreas Dinges, Prof. Dr. Karl-Heinz Küfer, Grete Kaffenberger, Andreas Meyer, Sandra Keth, Dr. Michael Bortz, Dr. Alexander Scherrer, Jasmin Kirchner, Dr. Michael Schröder

1 *Monitoring a chemical production plant*

MODELING, SIMULATION AND OPTIMIZATION IN PROCESS ENGINEERING

The working group Modeling, Simulation and Optimization (MSO) in Process engineering was founded in 2012 as a co-operation between the Chair for Thermodynamics at the TU Kaiserslautern lead by Prof. Hans Hasse and the Optimization department. With well-equipped laboratories and a broad infrastructure this working group covers wide topics in process design.

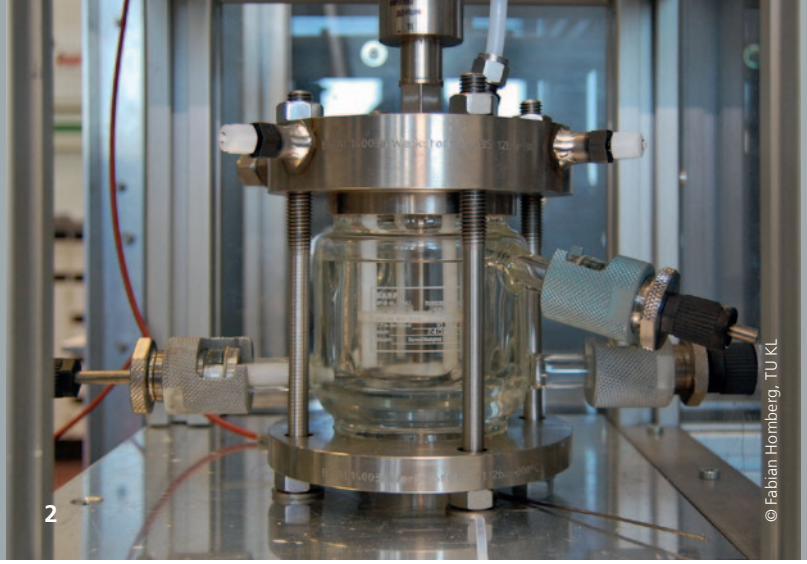
Data supported model-building from experiments, the model-based simulation and optimization including uncertainties and the iterative design of further suitable experiments are important tools of modern process design. The goal always is to separate or synthetize substances as good as possible, where "good" is context-dependent.

In this approach, two areas can be identified, where MSO plays a major role:

- Model building, verification and validation
  As to the substance models, this includes estimation of substance parameters such that macroscopical behavior, which is observed experimentally, is reproduced as accurately as possible. As far as the mini- and production plants are concerned, this includes e.g. the description in terms of equilibrium stages. This is a multicriteria problem, since generally, the accurate reproduction of all experimental observations simultaneously with one set of simulation parameters only is not possible.

- Determining of and keeping good operating points of production processes, such that user-defined KPI's (Key Performance Indicator) are reached as well as possible. This problem is multicriteria as well, because typical KPI's are conflicting, like, for example, measures for quality and costs.

The workflow for both tasks is supported within the MSO working group with a broad spectrum of methods. Typically, the workflow starts with finding the adequate model and its adequate parameters, which appropriately describe the degrees of freedom of the model. A good model is not only supposed to describe given and reliable data satisfactorily, but also to predict outcomes of future experiments in regions where no measurements have been carried out so far. Therefore, statistical methods from data mining and hypothesis tests are at the beginning. By several visualization techniques, the engineer is given the opportunity to explore dependencies between the data. Relevant variables are identified; the user then has the opportunity to compare different models, where these models are analyzed with respect to their descriptive



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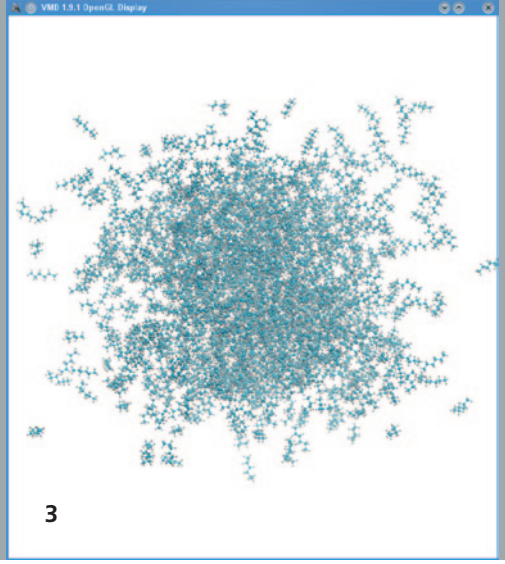

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and predictive qualities. In relation to the above mentioned points, the models typically include correlation functions when modeling non-ideal substances, or a suitable flowsheet of equilibrium stages to model real columns.

These models then are the foundation of a simulation-based optimization, where single solutions are embedded in the context of a solution ensemble. Within this approach, the planning is not only efficiently restricted to the set of best compromises. Additionally, the planer obtains insight into the neighborhood of a solution, especially into trade-offs, which are related to the improvement of one objective.

For both tasks mentioned above, a model hierarchy has been established. This model hierarchy allows it to identify interesting regions in design- and parameter space on a rather high level first, before exploring these regions in detail with a full simulation. This hierarchical approach not only saves time and allows the analysis of large areas in design- and decision spaces, but also might be the only possibility to find adequate starting points for the optimization with the full simulation.

For practical decision support as important as the knowledge of best compromises is information about robustness with respect to uncertainties in the model parameters. The planer will readily make a compromise in the KPI's, if therefore more robustness of the operating point is obtained. A sound quantification of the error, which results from the parameter estimate, and the reliable determination of confidence intervals are of central importance here. If the planer requires a reduction of the confidence intervals, then the steering quantities of the experiments are adjusted such that the experiments are done in regions where the reliability of the observations is maximized. The iteration of this workflow offers the chance to find reliable and practically relevant solutions to both tasks.

2 *Chemical reactor at the Chair for Thermodynamics, TU Kaiserslautern*

3 *Molecular dynamics simulation*

1

Luminal A	ER / PR positive, Her2 negative, Ki-67 below 14 %	Endocrine therapy
Luminal B	ER / PR positive, Her2 negative, Ki-67 at least 14 %	Endocrine therapy with/without CTX (includes Anthracycline and Taxane)
Luminal B	ER / PR positive, Her2 negative, any Ki-67	Endocrine therapy with CTX and anti-Her2-therapy (includes Anthracycline and Taxane)
Her2neu positive (not luminal)	ER / PR negative, Her2 overexpressed	CTX with anti-Her2-therapy (includes Anthracycline and Taxane)
Triple negative	ER / PR negative, Her2 negative	CTX (includes Anthracycline, Taxane and Cycloposphamide)

2

SENOLOGY ASSISTENCE

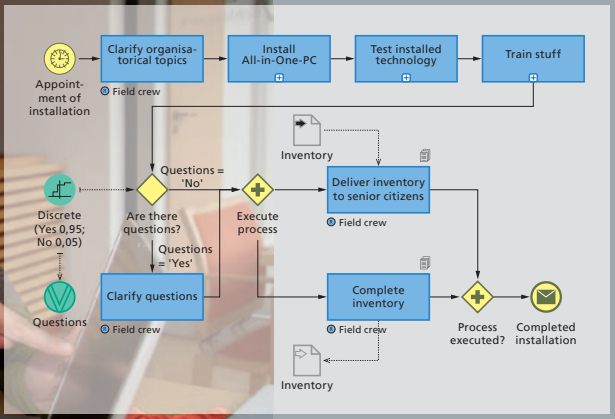
1 *Prototypical graphical user interface of SenoAssist*

2 *Tumor classification and therapy concepts according to St. Gallen consensus 2011*

Breast cancer is the most common cancerous disease among women with the highest number of death. Therapy typically combines the options of surgery, chemotherapy, antihormonal therapy and radiotherapy in a suitable way. The treating physician plans therapies according to his medical expertise based on standardized guide lines, scientific publications and clinical empirics. This requires the processing of a large amount of information and its efficient utilization for planning the best possible therapy for the current patient. However, this exclusive approach for establishing a constantly high therapy quality is difficult to follow in clinical routine because of the enormous and always present time pressure.

In the project "Senology assistance", the Department of Optimization develops the innovative planning software SenoAssist for Kliniken Essen-Mitte. This comprises at first the conception of suitable data models for processing the information and providing it for subsequent utilization. Then the medical planning processes are analyzed and emulated with methods of mathematical decision support. The software development of SenoAssist builds upon this data model and mathematical methods. Its main features are the easy administration and editing of patient cases, the automated search in the processed information for suitable diagnostic examinations, treatment options, etc. for the current patient case, and their intuitive visualization for further therapy planning.

SenoAssist thereby rids the treating physician from time-consuming routine work and allows for a focussing on his main task of therapy planning. The software provides him with a transparent information background for a qualified decision upon the next therapy steps. The use of SenoAssist in clinical routine is expected to significantly improve breast cancer therapy in terms of both planning time and achieved plan quality.



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SECURITY AND SUPPORT FOR SENIOR CITIZENS AT HOME – SUSI TD

The project "security and support for senior citizens through integration of technology and services" SUSI TD tests a special offer of technology and services for elderly people that enables them to stay at home and to remain independent as long as possible. The offer allows the seniors to feel more secure at home, supports the exchange with other seniors and improves the access to assistance and care services. SUSI TD is a pilot project part of the "Initiative Gesundheitswirtschaft Rheinland-Pfalz" (initiative for health care services) and is funded by the Ministerium für Soziales, Arbeit, Gesundheit und Demografie and the Ministerium für Wirtschaft, Klimaschutz, Energie und Landesplanung. Together with 30 senior citizens ageing from 70 of the region Trier and Konz the benefit of SUSI TD in everyday life is analyzed.

The senior citizens are taken care of by nursing care consultants and get an all-in-one computer and modern unobtrusive sensor technology installed at home. 20 contact and motion sensors attached to rooms and doors are wirelessly connected with the computer, are used to recognize situations of helplessness and support to call for help. The computer constantly receives and processes data from the sensors and can be used to inform family or an emergency hotline in case danger is recognized. The collected data are also trustfully used by the nursing care consultants to assess insidious changes in the behavior of the seniors early that might indicate an initiating insidious disease.

The integration of information technology with innovative health care consultancy requires a fundamental adaption of current processes in health care services. Therefore, the department Optimization of ITWM studies the economics of the approach of SUSI TD and develops a process model that covers the processes of all involved service providers (e. g., health care and technology providers).

The process model of ITWM can be used to simulate processes of future health care structures and can be used as a decision support tool. Different process variants can be simulated and process times and costs can be analyzed. The process model also represents a quality ensuring instrument of the research project because processes and key performance indicators are structured and documented. Furthermore, it serves as fundament for business models for innovative health care structures and assures their sustainable efficiency.

1 *Senior citizen is adviced in using modern communication technology*

2 *Business process model of installing SUSI TD technology*

FINANCIAL MATHEMATICS

- OPTION PRICING
- CREDIT RISK AND STATISTICS
- PORTFOLIO OPTIMIZATION
- INTEREST RATE MODELS
- INSURANCE MATHEMATICS

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The research focus and projects of the department reflect recent events in the greatest financial crisis in history. These are more significant than this annual report reveals, because the publication of some ongoing project findings is not or, not yet, permitted. These findings include topics like the measurement of liquidity risk, corporate portfolio sustainability management, or the investigation of suspected irregularities. The department is addressing new challenges in research and practice that arose from the consequences of the financial crisis like the use of interest rate swaps, once considered as risk-free collateral. One example in this respect is the extremely successful workshop conducted on the topic of basis-spreads and OIS discounting. Moreover, our research and consulting portfolio was significantly expanded as well as our customer base in 2012. The promising topics for the future are the modeling of electricity prices under the growing influence of alternative energy sources and the energy efficient calculation of risk. In addition, four doctoral degrees were completed in the department.

Option pricing

Options represent a source of risk as well as a means of managing risk in the financial markets. Despite the financial crisis, they are indispensable financial instruments for banks, asset managers, or insurers. Ever more complex forms and the need for more realistic share price and interest rate models continue to produce new challenges for valuation algorithms and software. In 2012, new and proven variations of Heston's stochastic volatility model were applied in industrial client projects. The recently developed tree-based method for pricing options in the Heston model are important components of future research and consulting projects in this area.

Credit risk and statistics

In addition to organizing workshops and industry projects in the area of credit risk, accounting fraud, and extreme value risk for banks and insurers, the research focus of this competence center are the two research projects "NORM" (News Optimized Risk Management) in the area of news analytics (an EU project in collaboration with Semlab from Holland and OptiRisk Systems from England) and "Robust Risk Estimation" sponsored by the VW Foundation (together with TU Kaiserslautern and others external partners). Nataliya Horbenko and Peter Ruckdeschel (together with co-author Taehan Bae) were the winners of the Operational Risk and Regulation 2012 Innovation Award in the category Paper of the Year 2012 for their work in the area of robust estimation of operational Value-at-Risk.

Portfolio optimization

Under the weight of the recent financial crisis, the determination of risk indicators and the risk management of large portfolios have become the focus of significantly greater attention than the actual optimization of the portfolios. The calculation of risk ratios for large portfolios, for example, Value-at-Risk or Expected Shortfall, demands highly efficient numerical methods in order to achieve the specified accuracy within a reasonable time. In this regard, the energy efficient calculation project mentioned above may provide promising possibilities. Another area of great interest involves capital guarantee strategies, for example, the so called CPPI strategy, which provides lower limits to protect against downside risk.

Dr. Gerald Kroisandt, Giles-Arnaud Nzouankeu Nana, Tatjana Lemke, Dr. Johannes Leitner, Dr. Roman Horsky, Dr. Jörg Wenzel, Andreas Wagner, Stefanie Grimm, Dr. Alexandra Kochendörfer

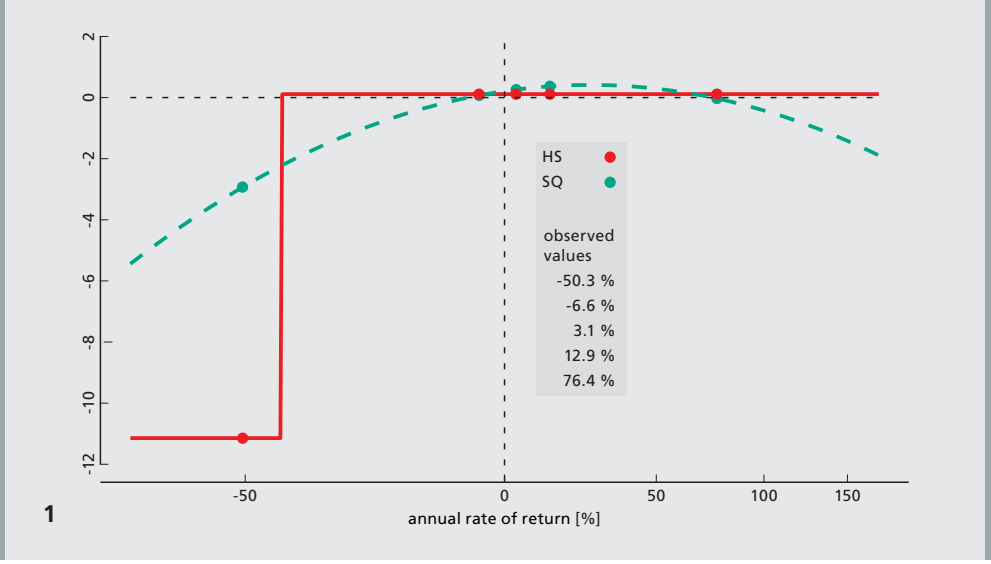
Interest rate models

As mentioned in the overview, we extended our know-how in the area of basis spreads and OIS discounting, in order to keep up with the highly topical developments in the interest rate market. We also organized comprehensive and successful workshops that focused on interest rates in support of the Year of the Interest Rate Guarantee, as 2012 was declared by German Society for Insurance and Financial Mathematics (DGVFM). Furthermore, we completed the update and commercialization of the multi-factor model (specifically, the 2-factor Hull-White model) implemented at ITWM. The modules could be flexibly applied as valuation methods and routines in various industrial projects. The modeling of energy prices is related to the interest rate model and is described in a separate article.

Dr. Johan de Kock, Dr. Bernhard Kübler, Nora Imkeller, Dr. Peter Ruckdeschel, Dr. Sascha Desmettre, Prof. Dr. Ralf Korn, Dr. Christina Erlwein-Sayer, Dr. Tilman Sayer

Insurance mathematics

The focus of the actuarial mathematics group in 2012 was in the area of interest rate modeling for insurers, particularly with regard for guarantees in the present phase of low interest rates and asset-liability management. In 2013, efforts are being made to acquire EI-QFM research and consulting agreements for financial mathematics products and methods among the members of the European Institute for Quality Management. Potential research areas for this are certification of actuarial software and pension plan products.



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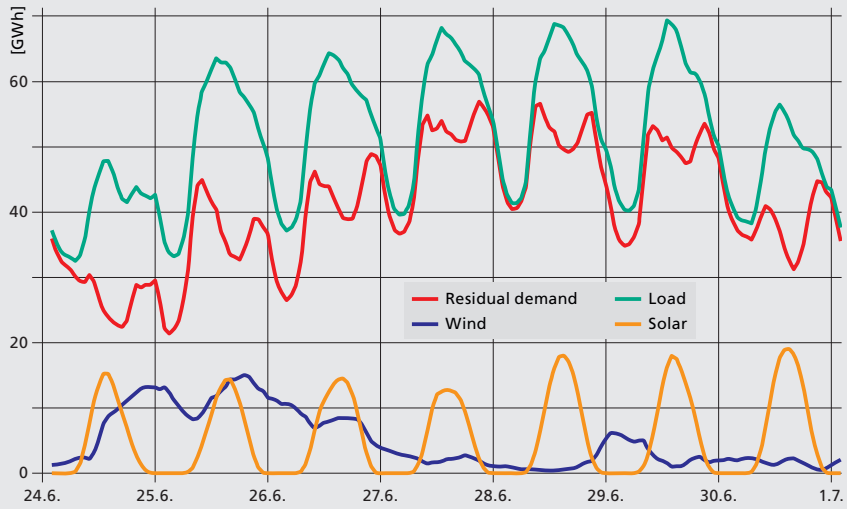
LONG TERM MARKET RISK MANAGEMENT

1 *Influence of single observations on 99%-VaR for 10.5% return and 30% volatility*

The risk of financial assets depends to a large extent on the investment horizon. Normally, the riskiness of an investment grows with an increasing time horizon. This becomes even more severe since estimation imprecision also increases for longer time periods. These longer periods are required by regulatory standards for long term risk management such as the MaRisk (German realization of the respective Basel agreement) with typical investment horizon of one year. Compared to this, short term risk prediction is a rather simple task – for trading purposes, it is customary to look at time frames ranging from only a day to a week. Our investment horizon is one year.

Risk exposure of a financial asset is measured by the well-known value at risk (VaR), a concept which has been used since the 1990's. According to the VaR, risk is determined as a particular quantile of the loss function, typically evaluated at levels 95 or 99 percent. Essentially, there are two approaches for VaR estimation: The first one is based on some parametric model for the distribution of the stock price process; assuming normally distributed returns, this amounts to estimating volatility. In this setting, by means of the so-called square-root-law (SQ) one can readily scale short term volatilities to longer time periods. The other, non-parametric approach uses the empirical quantile to estimate the quantile of interest of the loss function. In our context, this is referred to as historical simulation (HS). To this end, one has to gather a sufficient amount of historical data and to assess the yearly returns. In contrast to common quantile estimation, financial institutions have to deal with dependent observations. More precisely, autocorrelation effects emerge at three levels: In the data itself, in the course of the estimation procedure and also in the context of an ex-post validation.

Despite autocorrelation effects, neither of the two approaches leads to a systematic bias. However, variation of the VaR estimates increases compared to the situation with independent observations. HS makes fewer assumptions than SQ, but when SQ-assumptions are fulfilled, SQ necessarily performs better than HS. Moreover, HS estimates are strongly affected by only a few extremal observations, see figure. To systematically investigate the performance of the different approaches, we carry out empirical analyses on the basis of numerical simulations with model parameters calibrated to market data. Starting with data fits of suitable models for daily asset returns, specifically allowing for correlated volatilities, by means of Monte Carlo simulation, one-year risk estimates can be derived. Although autocorrelation effects in the daily data become less visible in the yearly aggregates, they do propagate and remain significant. An overall decision on whether to recommend HS or SQ so far cannot be taken, though: both approaches have been preferable in some considered situation.



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STRUCTURAL ELECTRICITY PRICE MODELS

In the project "Applied System Modeling for Renewable Energy" we investigate the effects of the German energy transition from a financial mathematical point of view and develop new models for electricity prices (www.applied-system-modeling.de).

The generation of electricity from renewable energy sources (especially wind and photovoltaic) has increased rapidly in Germany during the last years. According to the EEG (German renewable energy law) electricity generated from renewable sources have to be transferred to the power grid. The producer is paid a fixed amount for doing so. This practice has considerable influence on the wholesale prices of electricity, which (in the case of Germany) is traded on the EEX and EPEX.

Generally the EEG approach leads to lower market prices. During periods of temporary peaks in the renewable electricity generation (mostly due to the volatile wind situation) the prices can even be negative. Photovoltaic, on the other hand, leads to a new situation and to a reduction in the peaks. The price structure of electricity changes accordingly and follows the structure of the residual load. The residual load consists of the total demand minus the portion due to renewable energy sources and is shown in the figure above.

Existing electricity price models cannot adequately account for risk due to the high volatility of renewable energy sources. Andreas Wagner extended the class of structural electricity price models in his Ph.D. thesis. This extended class of models can take power generation from wind and photovoltaic into account. Structural models model the supply and demand separately. The market price is the intersection of both curves. This class of models is particularly appropriate for modeling the electricity market, since supply and demand have to match in the case of electricity. Furthermore, the structure enables one to analyze future effects which result from the increase in renewable energy.

1 *The combined demand of electricity and the generation by wind and photovoltaic during the last week of June 2012. The electricity prices follow the residual load, which is inadequately modeled in existing models.*

1

ESR – EFFICIENT ACCELERATION OF SIMULATIONS FOR RISK MEASUREMENT AND MANAGEMENT

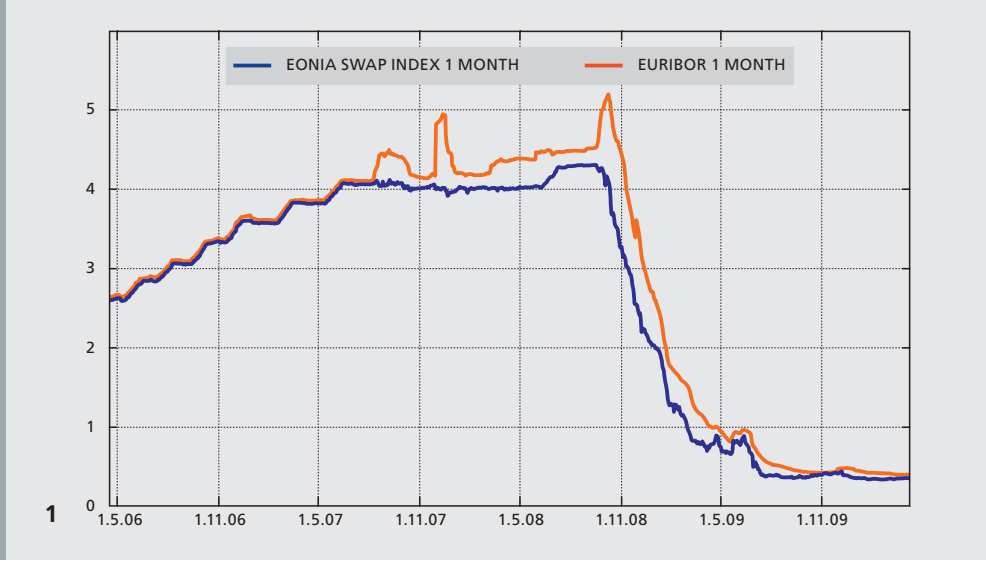
1 *View of an energy-efficient server room at ITWM*

Within the BMBF-project ESR, we develop a software demonstrator tool with partners from industry and academia with the purpose to accelerate selected and practice-oriented algorithms in the field of financial mathematics. The demonstrator offers a base of a commercial product. Our main cooperation partners are our long-time client Assenagon Asset Management SA (Munich) and the chair Microelectronic System Design of the University Kaiserslautern. The project runs for three years.

The financial crisis in 2008 and the consequences worldwide reasserted the importance of adequate procedures in the field of risk management. As one result of the crisis, governments and bank regulators explicitly tighten the requirements on risk management in banks and insurance companies (e. g. the planed reforms Basel III or Solvency II). The resulting demand for exact and promptly available risk key figures automatically implies the development of adequate financial models and their efficient implementation. In most cases this is done using CPU- and processor-intensive numerical methods. Even on highly specialized computer clusters, these computations often take up to several hours on the current state of technology.

Besides computation time, simulating risk scenarios with defined or stochastic input parameters is energy-intensive. Preparatory work done by the university group showed that excessively using energy-efficient accelerator architectures (e. g. through reconfigurable Field Programmable Gate Arrays, so called "FPGAs") in combination with highly specialized valuation methods in the field of risk management can save far more than 90 % of the energy.

Within the project we make the actual FPGA technology available to users in the financial and insurance sector. We provide an application-specific user interface adapted for the needs of risk managers and quantitative analysts. Here the technical challenges are to maintain flexibility when describing products, models and algorithms while simultaneously using efficient dedicated accelerator architectures.



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WORKSHOP SERIES "MODERN APPLIED FINANCIAL MATHEMATICS"

Based on our experience in the previous year, we also presented a series of 9 workshops at ITWM in 2012. The series, entitled "Modern Applied Financial Mathematics", was in high demand and was augmented by workshops which we presented in London in cooperation with OptiRisk Systems. New workshops were included into the program and the existing workshops were revised to reflect our devotion to communicating the latest research results to the finance and insurance industry. The workshops covering topical themes in the finance industry, e. g. Interest Rate Models and Base Spread and OIS Discounting, were particularly popular.

1 *Base Spread Curve-EONIA-EURIBOR*

The two-day workshop on interest rate models first covers several parametric short rate models which are used extensively in the industry. These models have the advantage that they have few parameters and that the derivation of many explicit pricing formulæ is simplified considerably. Furthermore, there are variants of these models which perfectly fit the current interest rate curve. Short rate models, on the other hand, have disadvantages which one should keep in mind. Simple cases of these models lead to unrealistic interest rate curves. These models do not always allow stable calibrations and in the cases where perfect calibrations are possible, they tend to give the false impression of perfect modeling. The second part of this workshop deals with widely used multifactor interest rate models, e. g. the LIBOR Market Model or the Two-Factor Hull-White Model which has been implemented at the ITWM.

The effect of the financial crisis of 2007 can be clearly seen by looking at base spreads and OIS Discounting. Investment alternatives which used to seem equivalent, now give rise to different returns. An example of this is the spread between the one-month-EURIBOR and the one-month-EONIA-Swap-Index (Overnight Index Swap). In practice this means that secured positions (EONIA-Swaps) have lower returns than positions at a bank with a first-class rating (EURIBOR). This has lead to two major paradigm shifts in derivatives pricing. On the one hand OIS (Overnight Index Swap) Discounting has become the market standard for pricing secured derivatives. On the other hand classical interest rate models can no longer satisfactorily reproduce the prices of swaps and other interest rate products. Models with more than one interest rate curve (so-called multi-curve models) have become the de facto market standard. In the current situation it is essential for practitioners to have a thorough understanding of OIS Discounting and multi curve models in order to obtain prices which are close to market prices for derivatives and interest rate products.


KUKA

MATHEMATICAL METHODS IN DYNAMICS AND DURABILITY

- STATISTICAL MODELS FOR USAGE VARIABILITY AND RELIABILITY
- SYSTEM SIMULATION
- CAE-DURABILITY
- NON-LINEAR STRUCTURAL MECHANICS

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The department MDF is developing simulation methods and models for dynamically loaded mechanical and mechatronic systems. Statistical methods and optimization processes are used to deal with the broad range of use cases and variants. Multi-body simulation (MBS) and Finite Element Methods (FEM) are deployed for system and component analysis. In our industrial projects we deal with reliability, durability, structural dynamics and system dynamics primarily in vehicle industry.

The department coordinates the activities of the Fraunhofer Innovation Cluster Digital Commercial Vehicle Technology (www.nutzfahrzeugcluster.de) and works with the industrial partners Bosch, BPW, Daimler, John Deere, Liebherr and Volvo on the projects "usage variability", "energy efficiency", "ground interaction simulation", "tire simulation", "on-board simulation" and "simulation of cables and hoses". Our new geo-referenced system Virtual Measurement Campaign (VMC) was launched in 2012 and is currently being evaluated at DAF, Daimler, MAN, Scania and Volvo.

Statistical methods for usage variability and reliability

We develop and deploy statistical methods for analyzing the product usage variability in view of reliability, durability and energy efficiency. Statistical methods play a major role in product reliability and durability engineering. Especially in reliability engineering statistical methods are key. Our software product JUROJIN is designed to support and optimize the statistical planning and analysis of durability tests. Planning and evaluation of measurement campaigns for service loading and the derivation of design targets is supported by our software USIM.

System simulation

In vehicle and system development processes it is essential to numerically simulate physical properties early and in various phases of the development process. Thus development stages with respect to attributes like vehicle dynamics, NVH, durability and the behavior of assistance systems can be qualified and improved. For different attributes and in different development stages obviously different model complexities and different numerical effort are appropriate and possible. Hybrid and interactive simulation to include electronic control units become more and more important.

A special focus in system simulation is to develop methods for invariant system excitation. Furthermore we develop and apply methods for tire simulation and ground interaction simulation.

CAE-durability

The fatigue life estimation of components essentially relies on the stresses and strains induced by the loads acting on the component (section forces). To determine the section forces appropriate system simulation (multi-body simulation) are used, whereas the local stresses and strains are calculated by FEA methods. Especially in cases, where multiple non-proportional time-dependent loads are acting on the component, a pure static analysis is not sufficient for the assessment of the fatigue life. Instead, the local stress-strain histories are needed.

Non-linear structural mechanics

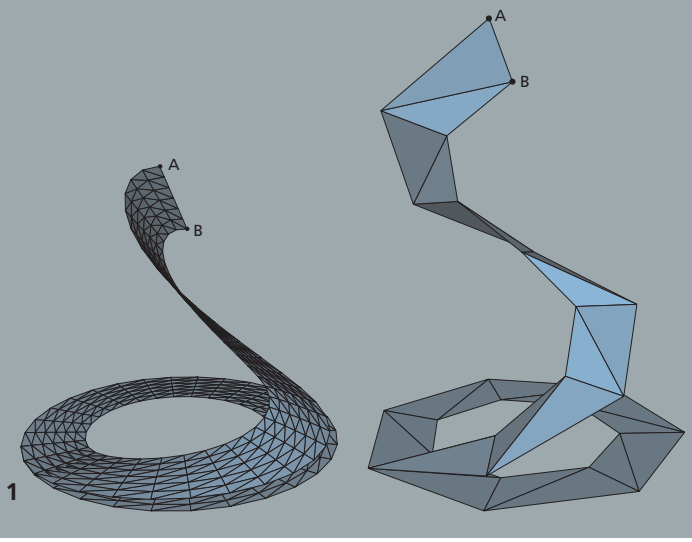
The department MDF is dealing with the modeling and simulation of highly deformable components and structures such as tires, rubber bushings, air springs, cables and hoses. Different levels of modeling are covered, ranging from computationally expensive continuum mechanical FE models to simplified macroscopic models with high performance.

Based on our CDTire simulation technology we have developed a new 3D shell based model that combines detailed physics and geometry resolution with the transient simulation performance of MBS models.

Virtual assembly planning requires a fast and physically correct description of the behavior of cables and hoses. Our software IPS Cable simulation, jointly developed with the Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC, allows the interactive simulation of cables and hoses in real-time.

Michael Roller, Dr. Eder Annibale, Jan Kleinert, Dr. Andrey Tuganov, Steffen Polanski, Sonja Baumann, Michael Kleer, Michael Horcicka, Dr. Clément Zémerli, Christian Goldmann, Fabio Schneider, Thorsten Weyh, Thomas Stephan, Dietmar Weber, Axel Gallrein, Dr. Manfred Bäcker, Dr. Andrey Gizatullin

Dr.-Ing. Lilli Müller, Dr. Michael Burger, Oliver Hermanns, Christine Rauch, Sebastian Seifen, Dr. Nikolaus Ruf, Michael Lübke, Alexander Lemken, Dr.-Ing. Joachim Linn, Dr. Anja Streit, Dr. Klaus Dreßler, Dr. Michael Speckert, Oliver Weinhold, Martin Obermayr, Dr. Stefan Steidel, Ekaterina Kruglova, Thomas Halfmann, Dr. Sascha Feth



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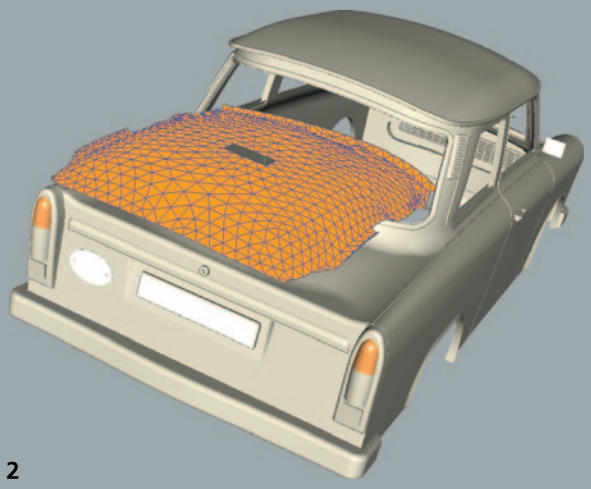


2

ASSEMBLY SIMULATION WITH FLEXIBLE SUFACES

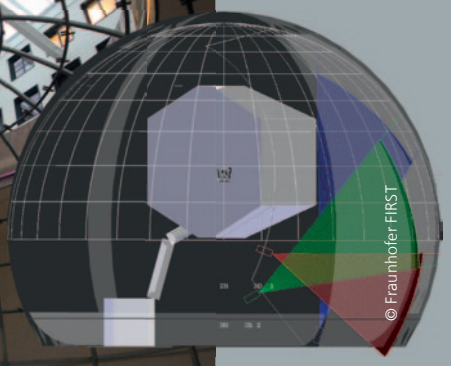
1 *Large deformation in discrete flexible surfaces; example, a slit disk – a qualitatively correct simulation of the deformation is possible even with a very rough discretization.*

2 *Practical use of discrete flexible surfaces (GeoMec example application): Simulated deformation of a typical roof liner geometry using the software prototype "IPS Shell Simulator" developed by FCC and ITWM*

The validation of assembly processes is an important part of virtual product development. The joint R&D efforts of ITWM and Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC have contributed significantly in recent years to making assembly simulations possible not only for rigid CAD geometries, but also for flexible structures. In simulations of virtual installation processes of cables and hose-like assemblies (i. e., long and thin structures), interactive manipulation is already state of the art technology.

This is not the case, however, for flexible surface structures that often appear in the design of vehicle interiors (roof linings, trims, the A, B, and C columns, door panels, floor mats). In the BMBF research project GeoMec, ITWM has developed, in collaboration with the Institute for Numerical and Applied Mathematics at the University of Göttingen, the mathematical groundwork to enable discrete descriptions of flexible surfaces while preserving their major geometric properties. Using methods from discrete differential geometry, it is possible to produce a qualitatively correct discretization of the deformation behavior of a flexible surface even on a very rough mesh (Figure 1). The quantitative agreement of discrete surfaces with the behavior of the continuous limit models (a geometrically exact shell) can be controlled by refining the details of the mesh, as required.

This corresponds exactly to the requirements for the modeling of flexible surfaces for application in the assembly simulation – one of the practical topics to be studied in GeoMec by ITWM together with Volkswagen AG as the associated industry partner. The goal is to qualify the methodical base developed in GeoMec with respect to a practical industrial application. The implementation of the software prototype jointly developed with FCC already makes it possible to simulate application related examples (Figure 2). Computing times show that by improving the numeric approach used to compute the mechanical equilibrium, interactive deformation of flexible surfaces on high performance desktop computers (also for discrete models with several thousand degrees of freedom) is nearly within our grasp.



HUMAN IN THE LOOP-SIMULATOR

Simulation of various vehicle types focuses on major aspects such as: energy efficiency, productivity, durability, and reliability. These aspects have non-stationary characteristic and are acting over long time periods. Thus it is required that all external inputs acting on the vehicle are considered and properly represented. The external inputs include not only vehicle loads but also direct inputs originated from the human operator.

Ideally machine durability analysis should be performed using statistically significant number of prototypes under real conditions and for all possible usage scenarios. Due to the complexity of this approach only selected cases can be considered. The use of prototypes in early development stage is often not possible due to modular nature of the development process. The better solution, given technical and financial perspectives, is an interactive simulator. The interactive simulator facilitates complex simulations and investigations of the operator influence in greater detail together with low risk.

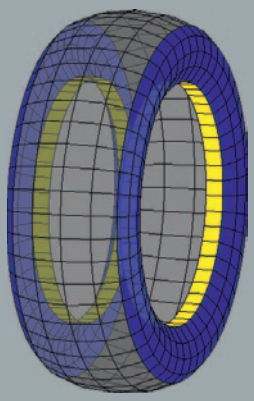
For this purpose at ITWM we have designed an interactive motion simulator based on an industrial robot. The seamless projection of the interactive scene is generated inside a spherical projection-dome with 10 m cross-section. To this end 18 projectors are installed inside the dome; they are synchronised and the image is adjusted to ensure realistic perception of the stereo projection. Design, layout, and construction of the projection system were carried out in collaboration with Fraunhofer FOKUS in Berlin. Programming of a scene graph, which calculates 3-dimensional scene for the visualisation cluster, was implemented in joint work with Fraunhofer IGD in Darmstadt. Various virtual environments can be built depending on the preferred scenarios. Off-the-shelf user interfaces in the cabin together with vibrational and acoustic feedback comprise complete immersion in the simulation. The cabin is a standard Volvo wheeled excavator cabin from which the virtual model is driven and operated.

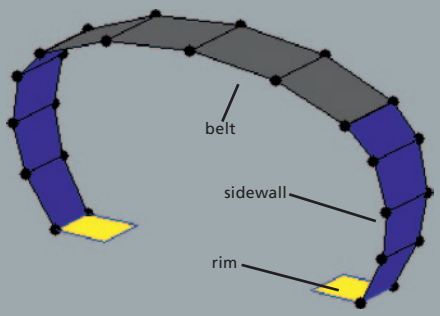
Since early 2013 the installation of the visualization system is completed and active research commenced. The main emphasis will be on the development of driver/operator models of commercial vehicles, as well as agricultural and construction machinery.

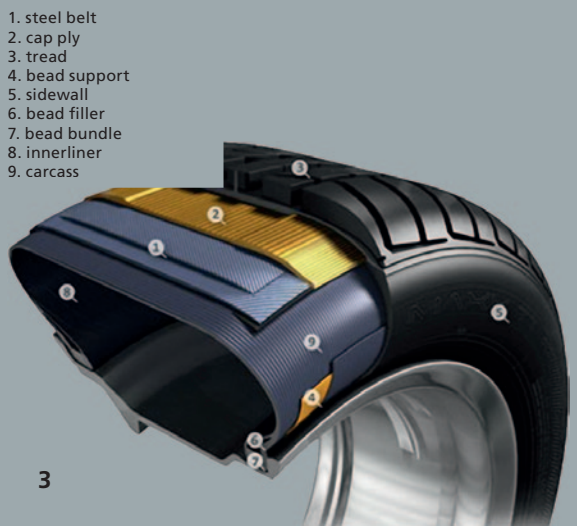
1 *Motion platform with excavator cabin*

2 *Skeleton of the spherical screen*

3 *Projection system setup*







1 2 3

CDTire3D EXTENDS THE APPLICATION RANGE AND ACCURACY LEVEL OF VEHICLE DYNAMIC SIMULATIONS

1 + 2 *Model mass distribution and cross section*

3 *Construction of radial tire*

CAE based methods are continuously accelerating the vehicle development process. Virtual vehicle models are driving over the digitized road surfaces of OEM's proving grounds, steered by virtual driver models. One of the key components in the load transfer process is the tire and the accuracy and reliability of the virtual load prediction scenarios crucially depends on the quality of the underlying tire model.

All commercially available tire models – including CDTire – have been developed in a time period where the available computer hardware delivered only a fraction of the computational performance available today. Simplifications in the modeling were accepted in order to ensure the applicability of the models in productive development processes. Due to these simplifications the application range and accuracy of the load prediction was limited. Motivated by unexploited potentials in the virtual development process, Fraunhofer ITWM developed a full 3D structural tire model that extends both the application range as well as the achievable accuracy for full vehicle scenarios.

The new CDTire3D additionally opens the door to extended tire parameterization strategies: local geometry based tire measurements can be used to reduce the set of needed tests to a minimum. It also enables the parameterization of tire types and sizes where the parameterization failed in the past due to the non-availability of suitable measurements. The new model is based on a detailed materialized shell representation of sidewall and belt to feature the deformation behavior of the load bearing structure. The shells are represented by discrete mass points with three dynamical degrees of freedom each. The elastic properties of the shell are realized by an anisotropic elastic membrane part and adaptation of the Kirchhoff-Love hypothesis for bending. The anisotropy of the tire is a direct consequence of the tire structure. The physical tire is built from different component layers like inner liner, carcass, steel belt layers, cap plies, tread etc., with most of these being reinforced by synthetic cords or steel wires. Each reinforcement layer introduces a materially preferred direction. All the characteristic component layers described above have a separate representation in the model. The main advantage of this description is that the model is completely configurable.

First studies have shown that the new tire model can reproduce the local deformation behavior of the load bearing structure in the same quality as a detailed FEM tire model. The run time for typical simulations is thereby in the same range as for other commercial available MBD tire models, which means it is an order of magnitude smaller than for FEM based tire models.

1

VIRTUAL MEASUREMENT CAMPAIGN – MODEL OF THE WORLD FOR VEHICLE ENGINEERING

Since several years, the MDF department develops methods to enable the application of geo-referenced and vehicle-independent data to support and improve the derivation of design loads as well as the assessment of energy efficiency based on statistical reasoning. The approach is mainly motivated by the usage variability and the resulting scatter in loads or fuel consumption, which is especially large for commercial vehicle fleets.

1 *Using layers for the description of the environment and the digital map data, analysis results may be generated and displayed.*

Most of the parameters influencing the performance of a vehicle are related to the conditions the vehicle is exposed to. For instance, if we know the road network including its curves and slopes, traffic lights and signs, speed limits and regulations, we can deduce valuable conclusions for the vehicle load and fuel consumption by appropriate simulation techniques.

On the one hand, we may want to collect vehicle-independent data such as distributions of curves and slopes or road and traffic properties characterizing a region and enabling the comparison of different markets. On the other hand, we may want to apply simple vehicle substitute models to estimate the impact of the conditions within a region on the longitudinal, lateral, and vertical dynamics, which also gives important hints for durability, reliability, and consumption assessments. Within these investigations, the emphasis is not on vehicle models but rather on the generation of relevant data for certain vehicle classes such as passenger cars or heavy duty trucks. This data may then be used for the evaluation and comparison of markets or regions with respect to their impact on the vehicles as well as for an improved planning of real measurement campaigns.

VMC provides an extensive group of methods and data collected in a dedicated database, which may be used as sketched above. Basic research and method development is ongoing since 2007 as a part of the Fraunhofer innovation cluster DNT (Digitale Nutzfahrzeugtechnologie). An implementation of the VMC concept for application in the truck industry is supported by a joint project with the truck manufacturers DAF-Trucks N.V., Daimler AG, MAN Nutzfahrzeuge AG, SCANIA CV AB (publ) und Aktiebolaget Volvo (publ). The database and the evaluation methods are embedded in a modern graphical user interface. Besides its intrinsic capabilities, the tool offers various options for importing or exporting data, e.g. for further analysis in some specialized extra tools. Because of the rapidly growing availability of potential data, for instance, traffic density information, and because of upcoming new requirements with respect to specific applications, we are continuously developing and extending the database as well as the methods collection. In addition, we are using VMC as a vital tool within our own specific industry projects.

COMPETENCE CENTER HIGH PERFORMANCE COMPUTING

- MULTICORE INNOVATION CENTER
- HPC TOOLS
- SEISMIC IMAGING
- VISUALIZATION OF LARGE DATA SETS
- PERFORMANCE OPTIMIZATION
- E-ENERGY, SMART GRIDS

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The performance and competitiveness of German and European industries increasingly depend on the ability to efficiently perform detailed simulation calculations. Essentially, no sector of the economy can afford to be without high performance computing: whether for the development of new functional fabrics, the optimization of machines and processes, the control of complex systems, or the identification of structures in large networks, all areas are affected. Accompanying this, there is a steady increase in requirements: Ever more precise models demand more extensive calculations and an ever larger volumes of data are being generated by increasing numbers of ever more accurate sensors.

At the same time, the production of hardware in recent years has become highly diversified. The typical supercomputer today consists of a large number of components: starting with multi-core CPUs, a single device may sometimes also contain graphics cards, an Intel Xeon PHI, and specialized FPGAs. In addition to volatile dynamic RAM and traditional hard drives, various forms of static semiconductor-based memory are available for data storage. The aim of increasing the theoretical performance relative to the start of the decade by a factor of 1000 to ExaFlop/s by 2020, points the way to machines with many millions of components, all of them interlinked by complex networks.

Today, just as parallel programming is already essential for smart phones and tablet computers, these ultra-scale machines will generate significantly more complex problems: How to integrate millions of components so they work together efficiently to solve a problem? What algorithms are suitable and what algorithms must be fundamentally reconsidered? What requirements does the problem being solved, in turn, place on the design of the machine and the associated system software? How to transport data quickly and efficiently to the computing units? What happens when an individual device fails?

The Competence Center for High Performance Computing has been seeking answers to these questions in a long and intensive cooperation with various industrial and academic partners, and is developing tools as well as integrated software solutions to manage the supercomputers. The Global Address Space Programming Interface (GPI) provides a programming model that is very well-suited for the programming of scalable, parallel software applications, i. e., software that is geared to effectively solve problems in distributed systems in a much shorter time. Switching to a global storage model and the truly asynchronous communication supported by GPI can be a huge benefit for critical sections of large applications in diverse sectors of industry. Mean-

while, this model is increasingly the preferred choice of international experts. GPI was developed last year for the CRAY computer company's supercomputer network, which opened a whole new market.

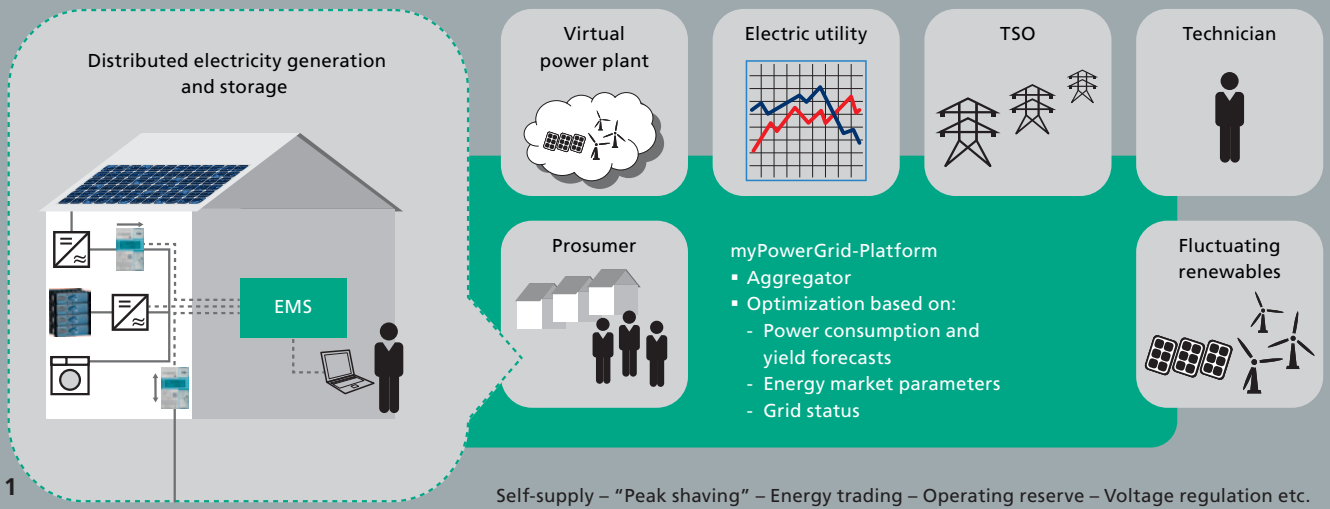
The use of GPI in application development proved to be very advantageous this year in the seismology sector. Over several years the CC HPC, in collaboration with industry partners, has developed software packets for angle migration (GRT) and for the visualization and analysis of prestack data (PreStackPro). These packets reliably meet the most stringent demands in operational use and distance themselves from all other available solutions in terms of speed and scope of performance. This is achievable not only because of the High Performance Computing know-how, but also because outstanding algorithms are used. In 2012, the seismic imaging group proceeded from ray-based migration methods with newer ways of wave field modeling (Reverse Time Migration). The Fraunhofer RTM method is, like all CC HPC implementations, highly optimized and scalable.

Another topic is end user support in the development and implementation of cluster applications. Using GPI as a basis, CC HPC is developing GPI-Space, a development platform and operating system that takes the concepts of the Cloud environment into consideration and further develops them. The result is a tool that greatly simplifies the development and fault tolerant execution of parallel software, leading to an improved productivity. For data storage, both seismic imaging applications as well as GPI-Space prefer to use the parallel file system FhGFS, also developed at CC HPC. This system distinguishes itself by ease of operation and superior performance and scalability. Last year witnessed once again the growth of the user base as well as improvements in the scope of performance and speed.

Last but not least, CC HPC is focusing on the management of Germany's transition to alternative energy sources. The primary aim is to manage the fluctuations in the production of alternative energy power. The projects mySmartGrid and myPowerGrid examine issues like how to decouple energy production from energy consumption, "virtual" consumer forecasts and shifting consumption times, optimization of private consumption as well as grid management of distributed battery systems. Much knowledge about the design and control of complex IT systems is flowing into the pursuit of a safe, environmental, and economic supply of energy. Green by IT is a new and growing field of business for the department.

Sven Breuner, Frank Kautz, Christian Mohrbacher, Bernd Schubert, Dr. Javier Lechuga Garcia, Clemens Koch, Bernd Lörwald, Lena Oden, Rui Màrio da Silva Machado, Dr. Jefferson Stafusa Elias Portela, Monika Schappert, Kai Krüger, Ely Wagner Aguiar de Oliveira, Egor Derevenetc, Alexander Petry, Dr. Mirko Rahn, Dr. Tiberiu Rotaru

Dr. Matthias Balzer, Dr. Daniel Grünewald, Jens Krüger, Dr. Leo Nesemann, Tobias Götz, Kathrin Fuchss Portela, Dr. Abel Amirbekyan, Dr. Dimitar Stoyanov, Dr. Franz-Josef Pfreundt, Frauke Santacruz, Dr. Martin Kühn, Dr. Norman Ettrich, Dr. Dominik Michel Dr. Dirk Merten, Bernd Lietzow, Dr. Alexander Klauer, Matthias Klein



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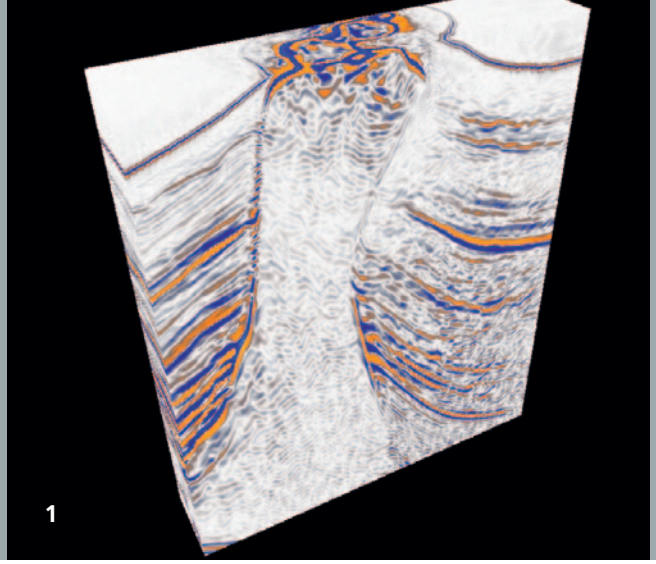
myPowerGrid – COORDINATED DISTRIBUTED POWER STORAGE

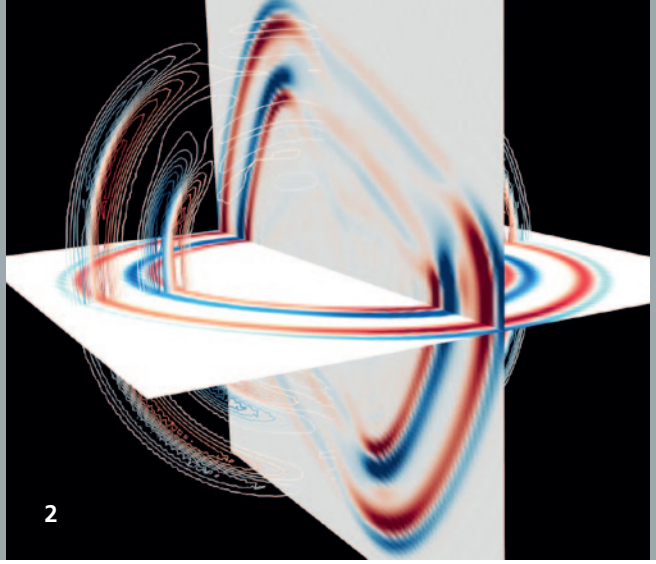
1 myPowerGrid integrates distributed storage technology to form a virtual bulk storage

Germany's future energy demand will be met largely by renewable energy sources such as wind power and photovoltaics (PV). However, the volatile character of wind power and PV is at odds with the necessity of keeping the balance between generation and consumption within the power grid. With respect to grid stability and uninterrupted service, this poses serious challenges for the management of energy generation. One option for balancing the inevitably increasing fluctuations is the short-term storage of electricity. Even today, electric energy is already stored by means of pumped hydro. A new development, however, is the adaption of chemo-electric storages, such as lithium-ion batteries. In addition, a market for combining energy storages with domestic PV installations is emerging. Given the decreasing feed-in tariffs while electricity rates are on the rise, own consumption of solar electricity becomes more economic than feed-in. Electricity storages are expected to improve the owners' own consumption ratios, thus lowering electricity costs.

Yet, managing domestic electricity storages with a view only on the single household in which they are installed, that is, with the sole purpose of increasing own consumption of locally generated PV energy, does not exploit the full potential of the storage. It can even be detrimental to grid stability: for example if wind power plants have to be shut down because the storages are discharged at the wrong time. Conversely, if during an energy deficit the stored energy is not fed in, other, mostly conventional power plants have to be started up needlessly. Furthermore, the storage would have significant idle times due to day-to-day and seasonal fluctuations in energy generation. The potential of these storages can be used more sensibly by not exclusively increasing own consumption, but by coordinated management based on grid state.

With myPowerGrid, we are in the process of developing a web platform making the first steps down the road towards coordinated, distributed electricity storage. Combining both public and private interest, an optimal management of the storages is ensured, in order to guarantee supply preferably wholly from renewable energy sources. The aggregated operation of storages enables a safe, ecologically sensible and at the same time economically optimized management by provision of many different services for utilities, transmission system operators, and virtual power plant managers. Among these are reduction of load and generation spikes ("peak shaving"), adaption of energy yield forecasts, inclusion of the virtual storage in combined, regenerative plants in order to provide reserve power, and participation in energy and reserve power markets.





SCALABLE REVERSE TIME MIGRATION FOR ELASTIC ANISOTROPIC SUBSURFACE MEDIA

Seismic depth migration methods use measured and pre-stacked reflected seismic data to compute an image of the Earth`s subsurface, which enables geologists to identify the locations of oil and natural gas fields. Thanks to today's high performance computing architecture, the Reverse Time Migration (RTM) method is gaining in popularity. In contrast to ray-based migration methods, such as the widely used Kirchhoff depth migration, RTM is based on wave field modeling that "solves" the wave equation. Computations using measured data simulate how the wave field had propagated through the underground rock formations before it was registered by the hydro- or geophones at the surface. Strong correlation between source and receiver wave fields result in visible migration amplitudes, that are due to local changes of rock or fluid fill parameters.

The practical advantage of RTM is limited today because the computations still make use of the acoustic wave equation. This represents an insufficient approach, especially for subsurface anisotropic rock formations. The aim of our current research is the changeover to the use of the correct elastodynamic equation of motion. In this case, not only a pressure wave field, but rather a wave field of 3-component vectors has to be computed for the particle displacements. In addition, the number of model parameters is significantly greater than for acoustic RTM. Therefore, the computation of the wave field propagation can no longer be executed on one computing node per seismic data source. We achieve a scalable RTM through domain decomposition, where the source is processed by several computational nodes. Optimal sub-domain sizing as well as overlapping the communication with the computation of the wave fields provides the perfect distribution without any time loss when exchanging the overlapped areas between the sub domains. It is once again advantageous to use GPI here as the parallelization software. In this way, a promising framework for elastic RTM has already been created. Mathematical-geophysical problems, such as an improved imaging condition for the correlation between source and receiver wave fields, more compact FD stencils or finite element methods for more exact modeling of the wave fields, and computation of the migration results depending on the reflected angle can now be processed and tested, not just individually, but in terms of their impact on the final migration results.

1 *RTM image of a synthetic salt dome model*

2 *Simulated pressure wave front in elastic orthorhombic material*

1

GLOBAL ADDRESS SPACE PROGRAMMING INTERFACE

1 CRAY Hermit at High Performance Computing Center Stuttgart

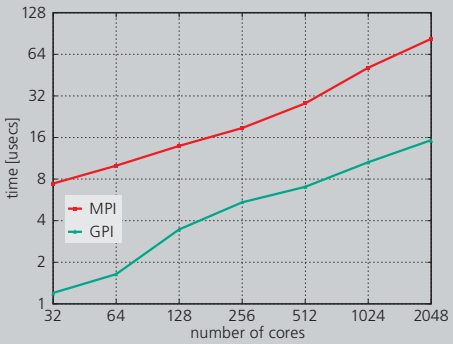
Nowadays, supercomputers are indispensable in almost every scientific research domain. They are considered to be one of the most important driving forces for the accumulation and gain of new insights. As such, they are important for the progress and the competitiveness of our society. The demand for increasing compute power is almost inexhaustible. Reasons are the necessity for more complex models and/or bigger input data which allow for better and more realistic results.

The required compute power is achieved by interconnecting an ever increasing number of processing units with fast networks. Here, the trend is clearly going towards heterogeneous systems, in which CPUs are supplemented by so-called accelerator cards like the Intel Xeon Phi or GPGPUs by Nvidia. Titan, currently the fastest supercomputer in the world (TOP 500 List, Nov 2012), is one example. It consists of 18688 CPUs and graphics cards, each. The necessity of an efficient partitioning of a given problem into smaller sub problems which can be concurrently solved by the processing units at an optimal load balance, becomes evident. Communication and synchronization between the processing units is inevitable. However, measured in terms of achieved floating point operations per second, the communication acts counterproductively for the efficiency and scalability of an algorithm.

Potential hardware failures also become an issue at such system sizes. Even if the probability for a single device failure is rather small, the total probability of failure becomes significant.

Hence, fast and resource failure prepared communication without interference with the actual computation is a necessary condition for scalable, efficient and productive code, not only in the industrial environment. The communication library Global address space Programming Interface (GPI), offered by the CC-HPC is facing these problems and is being continuously improved for years, now.

GPI implements a partitioned global address space. Each process hosts one partition of the global address space and makes it directly accessible to the other processes. Here, it does not matter whether the underlying physical memory is associated to a CPU or whether it is associated to an accelerator card. The unique performance of GPI is rooted in one-sided and asynchronous communication which is offloaded to the network infrastructure by the actual processing unit. The asynchronicity allows the invoking process to keep on working while the data is being transferred. At the same time, the computation of its communication partner is not interrupted since it is not involved in the one-sided call. Since the communication is offloaded to



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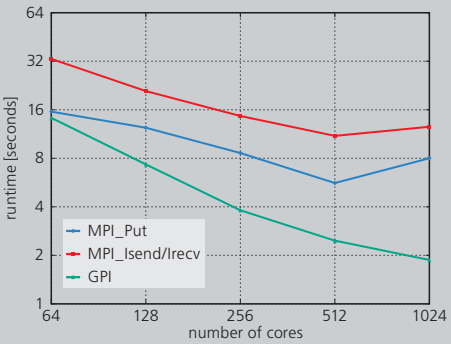

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the network infrastructure, the communication does not interfere with the computation. Mechanisms for minimal invasive pairwise synchronization are complementing basic communication calls. This yields minimal communication times and the performance of the actual computation is not disturbed. Thus, an algorithm can optimally scale.

The superior performance of GPI in comparison to other programming models is seen in many applications of completely different types. Stencil algorithms, i. e. algorithms with only local data dependencies to neighbors, formulated on structured or unstructured grids benefit in the same way from the programming model as difficult load balancing problems which arise in problems traversing very large graphs, for example.

In the GASPI project which is sponsored by the BMBF, the CC HPC establishes a de-facto standard of GPI together with its project partners from academia and industry. This de-facto standard is based on and supported by a broad basis of industry applications.

Beside Infiniband and RoCE ethernet, GPI is supporting the Cray Gemini network, now. Software on the Hermit Cluster at HLRS is already taking advantage of GPI. A system which belongs to the thirty most powerful supercomputers in the world, today (TOP 500 List, Nov 2012).

2 *Scalable Barrier GPI vs. CRAY MPI, 2×AMD Opteron™ 6276 (Interlagos), Gemini*

3 *2D-FFT: $N = 2^{15}$ GPI vs. CRAY MPI: 2D-FFT: $N = 2^{15}$, 2×AMD Opteron™ 6276 (Interlagos), Gemini*

FRAUNHOFER-CHALMERS RESEARCH CENTER FOR INDUSTRIAL MATHEMATICS FCC

- GEOMETRY AND MOTION PLANNING
- COMPUTATIONAL ENGINEERING AND DESIGN
- SYSTEMS AND DATA ANALYSIS

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FCC has since start 2001 completed more than two hundred fifty industrial and public projects. We have successfully cooperated with more than hundred companies from different branches. We have seen the power of our vision "Mathematics as Technology" and we are impressed and proud of the trust we enjoy from our founders Fraunhofer-Gesellschaft and Chalmers, from industrial partners, and from public research agencies.

In 2011 and 2012 the German Bund-Länder-Kommission and the Bundestag Haushaltsausschuss decided to give clearance for permanent institutional funding. After this, the founders have agreed on a timetable to identify and remove possible obstacles preventing widening the scope of the cooperation. Together with our partners Chalmers and the Fraunhofer industrial mathematics institute ITWM we cover a wide range of applications. In 2012 our cooperation included joint actions with four ITWM departments and with several Chalmers centres and departments: Wingquist Laboratory, Systems and Synthetic Biology, Fluid Dynamics, Biomedical Engineering, Mathematical Sciences, and Chalmers e-Science Centre CheSC Together with our partners we 2012 formed independent spin-offs Industrial Path Solutions AB and fleXstructures GmbH. We have signed contracts with these companies to secure focused professional marketing, maintenance, support, and adaptation of software developed by FCC and ITWM, to satisfy client demands. 2012 was again a successful one, in spite of a five per cent drop in total income, since the industrial income increased by thirty per cent. This brings us back to a relative industrial income close to forty per cent, which is our guideline value for a balanced financial mix. We had a small positive net result, as has been the case since start.

Our industrial clients are mainly from Sweden. We also have international clients from Europe, United States, and Japan. In 2012 we strengthened our links to the newly established Swedish – Brazilian Research and Innovation Association CISB with its Centre in São Bernardo do Campo, State of São Paulo.

The department Geometry and Motion Planning, working in close cooperation with the Chalmers Wingquist Laboratory, participates in the ten-year Wingquist Laboratory VINN Excellence Centre for Virtual Product Realization 2007 – 2016. In 2012 the department continued and extended several public projects, e. g., on automatic path-planning and line-balancing, sealing, virtual paint, flexible materials, co-ordinate measuring machines, and intelligently moving manikins. The software platform IPS for rigid body motion planning, robotics path planning, and flexible cable simulation is recognized through licensing by industrial clients in Europe, United States, and Japan. The department has substantial joint development with the ITWM department Mathematical Methods in Dynamics and Durability. In 2012 this co-operation generated two spin-off companies: Industrial Path Solutions AB and fleXstructures GmbH.

The department Computational Engineering and Design has continued and expanded its work on novel numerical methods and simulation tools for applications in fluid dynamics, structural dynamics and electromagnetics. The department collaborates with the ITWM departments Optimization, Flow and Material Simulation, and Mathematical Methods in Dynamics and Durability, and runs several multi-physics projects involving fluid-structure and fluid-electromagnetics interaction including the six-year project on innovative simulation of paper with Swedish paper and packaging industry. The department addresses medical technology in a project on epilepsy focus localization with Chalmers S2 and Sahlgrenska University Hospital. The department is a key partner in the project on virtual paint mentioned above.

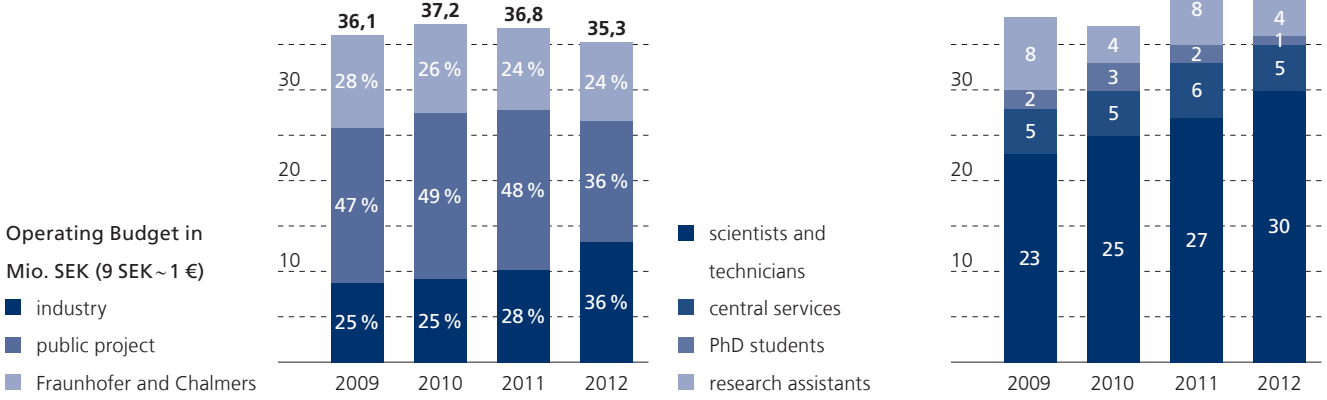
The department Systems and Data Analysis offers competence in dynamic systems, prediction and control, image and video analysis, mathematical statistics, and quality engineering. In 2012 the department has continued its activities in systems biology as partner in several EU projects and through cooperation with the ITWM department System Analysis, Prognosis and Control. Work on interactive pharmacokinetics and phar-

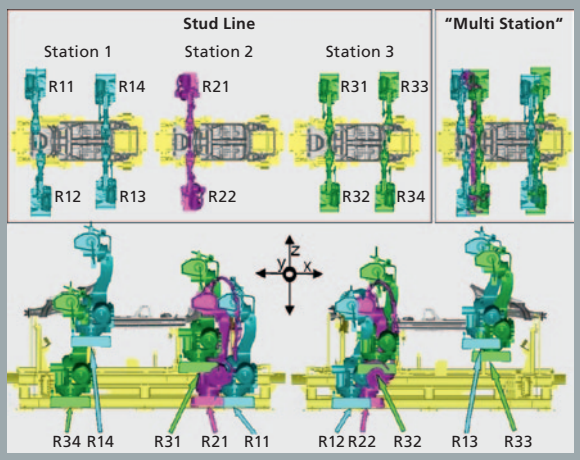
macodynamics has resulted in the software Maxsim2 for pharmaceutical industry and the department runs a three-year industrial project on specific applications in this area. Another industrial project to be emphasised is on modelling and analysis of multi-axial stochastic loads for cultivators together with expertise from Chalmers Mathematical Sciences.

In 2012 we were fortunate to recruit nine new co-workers. Our staff of applied researchers is a mix of PhDs and Masters of Science, where about half have a doctor's degree. In our model an MSc first works in industrial and public projects for two to five years. In this period we encourage participation in conferences and submitting papers to get a research flavour. Four years ago we initiated a campaign to offer an interesting option to Chalmers Master's students while boosting our base for future recruitments. We invite students from a handful of Chalmers and Gothenburg University international programmes with a mathematical profile to information meetings "Earn Money with Mathematics". We describe FCC and our activities, including the possibilities for talented students to be contracted on ten percent of full time, or half a day per week, for work at the Centre, and to do Master's thesis projects at the Centre with joint supervision from Chalmers and FCC. In 2012 we had seventeen Master's students working on this type of contract and nine Master's students doing their thesis projects at the Centre.

I thank my co-workers at FCC for your excellent work and my colleagues at Chalmers and Fraunhofer ITWM for our fruitful collaboration. Since start the Centre has earned more than thirty million euros including more than ten million euros industrial income and performed four hundred full-time equivalents work. This is now my last report and I take the opportunity to thank you all for a great time and great achievements – it has been an honour and a privilege to work with you. I wish you all the best for the future and I warmly congratulate my successor Dr Johan Carlson to his new, exciting position!

Dr. Uno Nävert
Director of FCC





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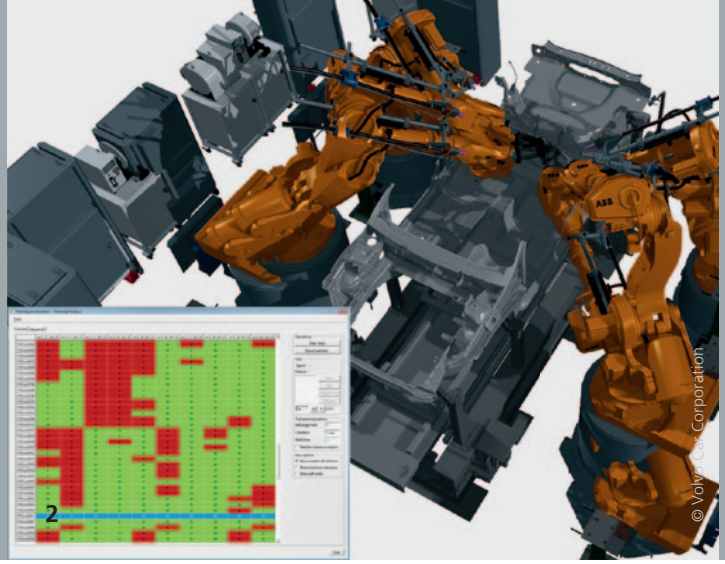

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AUTOMATIC PATH PLANNING AND LINE BALANCING

1 *Create a multi station by superimposition of the scenes and geometries of the line stations, with maintained robot positioning relative to the product (car body).*

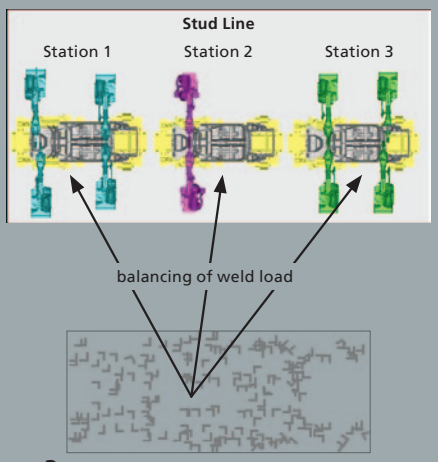
2 *Task Plan to find collision-free alternatives to perform each welding operation in the multi station.*

In today's automotive industry, although most development is done virtually, some decisions still lack a solid mathematical basis. In order to make the manufacturing engineering process more efficient, FCC and Wingquist Laboratory at Chalmers have worked with Volvo Cars, Volvo Trucks, Saab Automobile and Scania CV in VINNOVA funded projects to develop new methods and tools for automatic load balancing of welding lines.

Today, the margins of automotive manufacturers are tight and competition is fierce. The industry furthermore faces paradigm shifts regarding propulsion as well as styling, with environmental requirements ever-present. Effective product realization response is thus important. By targeting the car body, which is perhaps the most defining part of any car and also has a significant influence on safety, aesthetics, handling, fuel economy and top speed, it is possible to achieve significant improvements in terms of production efficiency and production equipment utilization.

A typical automotive car body consists of about 300 sheet metal parts, joined by about 4000 welds. Typical joining methods are spot welding, arc welding, gluing and stud welding. In car body assembly plants, the welds are distributed over several hundred industrial welding robots, which are organized in up to 100 stations. Sheet metal assembly is an investment intense type of assembly. Therefore the expensive equipment needs to be utilized to its full potential. The balancing of weld work load between the executing stations and robots has a significant influence on achievable production rate and equipment utilization. Robot line balancing is a complex problem, where a number of welding robots in a number of stations are available to execute an overall weld load. Each weld is to be assigned to a specific station and robot, such that the line cycle time is minimized. Line balancing efficiency depends on station load balancing, robot welding sequencing, path planning and effectiveness of robot coordination for collision free execution within each other's working envelopes. In general, robot coordination impairs cycle time by inserting waiting positions and signals into the original paths.

So far, no automatic simulation based method for weld load balancing over entire production lines has been developed. Furthermore, in industrial practice, weld load balancing is still manually conducted, based on experience and time consuming trial-and-error analysis in CAE-tools (Computer Aided Engineering). Therefore this work has aimed at developing automatic simulation based methods for weld load balancing over entire production lines to maximize equipment utilization as well as dimensional quality. Since the criterion of dimensional quality is coupled to cycle time and thus to equipment utilization, it is added as a second criterion.



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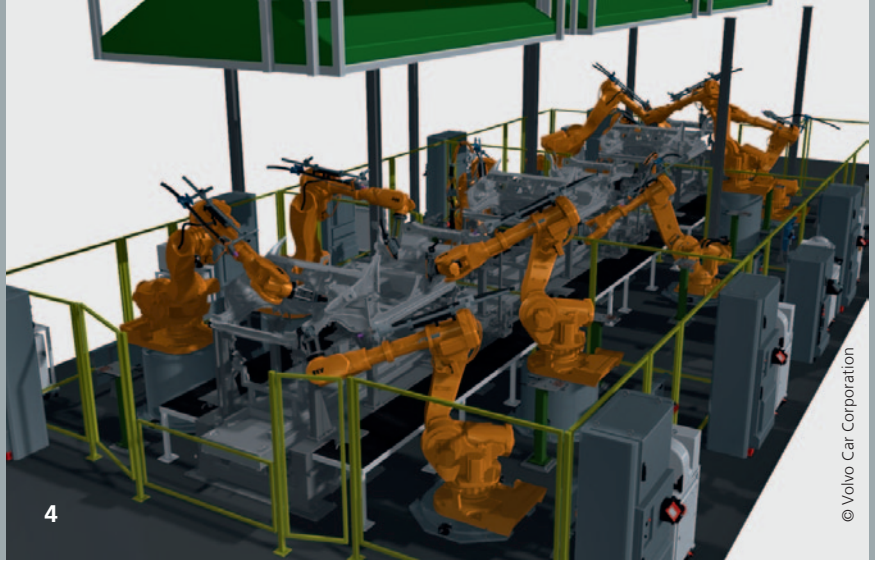

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The strategy to target the load balancing problem has been to treat identified station design parameters together, with respect to equipment utilization and geometrical quality, based on a chronological framework for virtual sheet metal assembly design, to utilize and further develop automatic path planning combined with discrete optimization techniques in order to automatically load balance, sequence and find collision free motions, to continuously implement the results in the FCC developed IPS software available for the project partners, since this way of working has proven to guarantee the usefulness of the project results both during and after the project, and to use real industrial case studies to quantify the level of success in reaching the objectives.

Automatic simulation is now a reality through a world first method. The new method has been successfully applied in vehicle programs, will be rolled out to all vehicle programs and body shops at Volvo Cars, and is described in five principle scientific publications. The project has also resulted in a PhD thesis in product and production development at Chalmers.

Application of the automat line balancing method shows

- 25 % better equipment utilization, and
- 75 % reduction of offline programming- and commissioning costs.

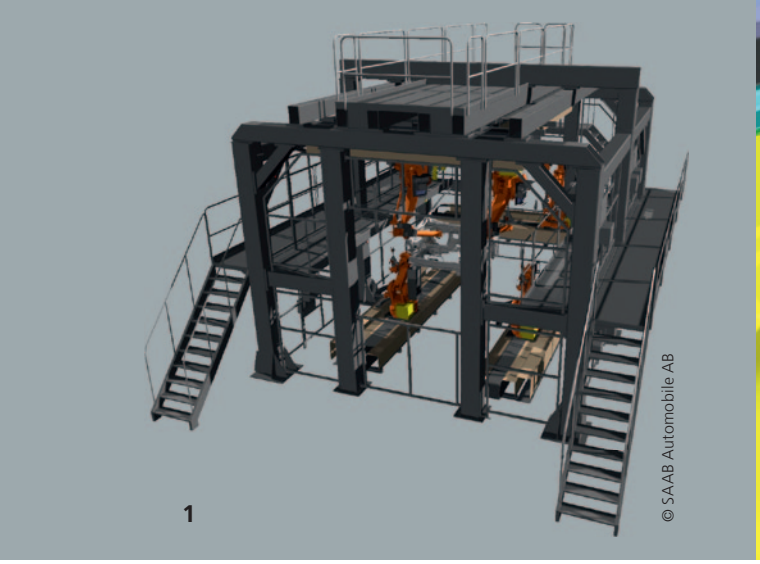
The method also enables

- Concurrent manufacturing engineering and product development
- Increased insensitivity to late changes
- Backup solutions for robot break downs.

Furthermore, the project won the Volvo Cars Technology Award in the category “Research”.

3 *Distribute the welding operations between the stations and robots to minimize estimated cycle time and with preference to robot weld separation within and between the stations.*

4 *Minimize cycle time by integrating balancing, sequencing, path planning and coordinating on the welds distributed to each Station in the previous step.*



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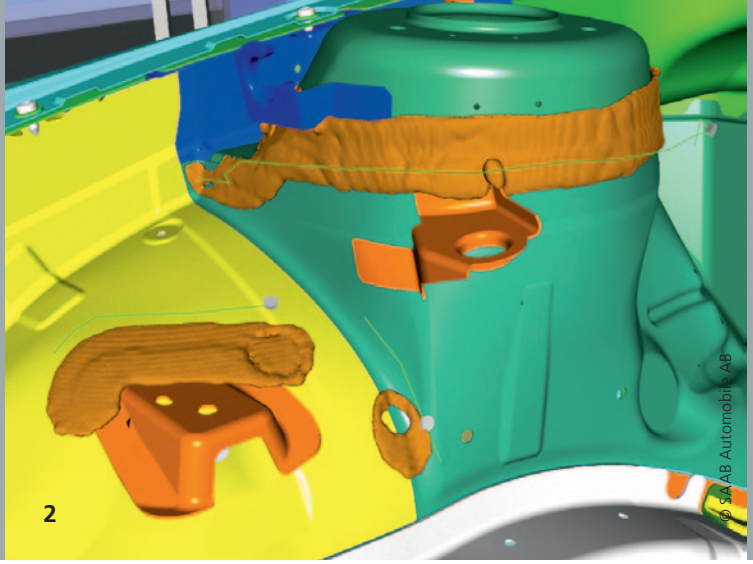

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VIRTUAL PAINT SHOP: SEALING SPRAY

1 *Sealing station at SAAB Automobile modeled in the IPS Virtual Sealing software*

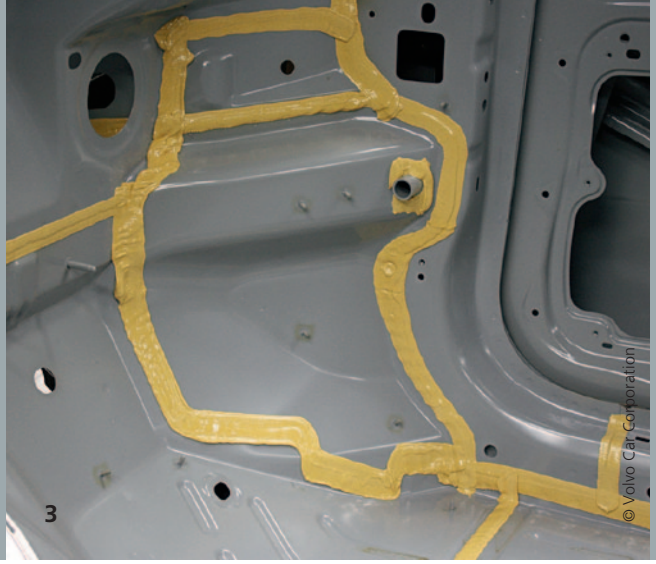
2 *Simulation of sealing application on seams in the engine compartment using the IPS Virtual Sealing software*

The goal of this ongoing project is to develop new methods, algorithms and simulation tools for paint and surface treatment processes in automotive paint shops. The project is part of Vinnova's FFI program towards sustainable production technology and our research partners are Volvo Car Corporation, Scania AB, AB Volvo, Swerea IVF, and General Motors North America.

The main processes in automotive paint shops are electro coating, sealing and cavity waxing, spray painting and oven curing. The complexity of the processes characterized by multi-phase and free surface flows, multi-physics, multi-scale phenomena, and large moving geometries, poses great challenges for mathematical modeling and simulation. The current situation in the automotive industry is therefore to rely on individual experience and physical validation for improving the paint and surface treatment processes. In off-line programming of the robots it is a great advantage to have access to tools that combine automatic path planning with fast and efficient simulation of the processes to be able to reduce the time required for introduction of new models, reduce the environmental impact and increase quality. The development of such tools is the aim of the ongoing Virtual Paint Shop project.

Sealing material is applied to automotive bodies to cover cavities and seams, where moisture might otherwise create a corrosive environment, and also to dampen noise. In the order of 50 meters of material is used for a car. This is a complex multi-phase flow application and the material flow in air and on the target must be considered. The sealing material is a non-Newtonian fluid which is strongly shear thinning such that the viscosity depends on the shear rate. A Bingham fluid can be used to model the rheology of the material, where the yield stress and plastic viscosity parameters are determined from rotational rheometer experiments.

There are different types of nozzles used to apply the material including the hollow-cone, in which a curtain of sealing material is sprayed on the target, and the flat bead nozzle. To verify the simulations the resulting width, thickness and shape of applied material on test plates as a function of time and spraying distance have been compared to experiments. The agreement is in general very good. Several more complex geometries have also been successfully simulated as shown in the figures. The efficient implementation makes it possible to simulate application of one meter of sealing material in less than an hour on a standard computer, and it is therefore feasible to include such detailed simulations in the production preparation process and off-line programming of the sealing robots.



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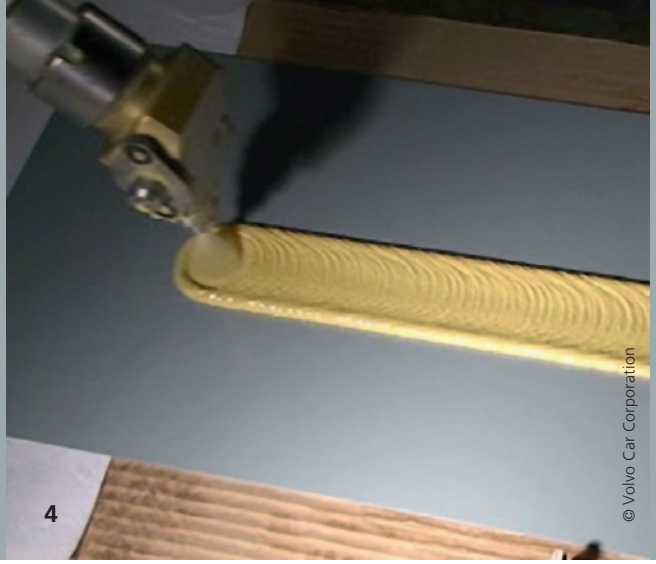

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To achieve this break-through in simulation speed compared to earlier approaches the FCC software IBOFlow has been used. IBOFlow is an incompressible Navier-Stokes solver, which is based on a finite volume discretization on a Cartesian octree grid. The octree grid can be dynamically refined and coarsened, and unique immersed boundary methods are used to model the presence of objects in the fluid. This simplifies the pre-processing and modeling of moving objects can be accomplished with virtually no additional computational cost. The multi-phase flow is handled by the novel volume of fluids (VOF) module in IBOFlow.

The IBOFlow software has been integrated in the in-house math-based software for virtual product and production realization, IPS. In the IPS Virtual Sealing module collision free curve following algorithms are used to automatically generate the robot paths. The automatic robot path planning includes, task planning to find promising configurations and motions that can follow each sealing curve, sequence optimization and motion planning to select one solution for each seam and connect them by efficient motions and in a sequence minimizing the cycle time.

The first version of the IPS Virtual Sealing software will be delivered to our research partners during the spring 2013. Currently we are also working on simulation tools for the other automotive paint shop processes spray painting, electro dipping and oven curing. In particular, the IPS spray paint application has been successfully validated in several measurement campaigns during 2012. A commercial release will be made during 2013.

3 *Seam sealing application at Volvo Cars in Torslanda*

4 *Application of sealing material on a flat plate using a hollow-cone nozzle. The applicator moves from right to left with constant velocity.*

TALKS

Amirbekyan, Abel
Seismic Reflection Tomography: Theory and Implementation
Universität Siegen, February

Andrä, Heiko; Iliev, Dimitar; Iliev, Oleg; Kabel, Matthias; Kirsch, Ralf
Fluid-Porous Structure Interaction (FPSI) in the Context of Simulations of Filtration Processes
NAFEMS European Conference: Multiphyics Simulation, Frankfurt, October

Andrä, Heiko; Iliev, Oleg; Kabel, Matthias; Kirsch, Ralf; Lakdawala, Zahra
Models and methods for the simulation of filter elements
11th World Filtration Congress, Graz (A), April

Andrä, Heiko; Kabel, Matthias; Spahn, Johannes; Staub, Sarah; Steiner, Konrad
Schnelles Lösungsverfahren der Lippmann-Schwinger-Gleichungen für die Multiskalensimulation von Composites
NAFEMS Konferenz, May, Bamberg

Arne, Walter; Marheineke, Nicole; Meister, Andreas; Wegener, Raimund
Finite Volume approach for instationary Cosserat rod model describing viscous jets
17th Europ. Conference on Mathematics for Industry, Lund (S), July

Arnold, Michael
Automatic plant identification by bag of visual words
Joint Workshop CMM – ITWM, Kaiserslautern, October

Bare, Zoufine
Asymptotic dimension reduction for linearized contact of thin fibers and simulation of textiles based on 1d models including large deformation
Seminarvortrag, Universität Erlangen-Nürnberg, May

Bare, Zoufine
Asymptotic dimension reduction of a unilateral contact problem of a beam including friction
Second international workshop on Mutiscale Modelling and Methods, Universität-Jean-Monet, St. Etienne (F), October

Bare, Zoufine
Asymptotics for thin elastic fibers in contact
GAMM-Jahrestagung, TU Darmstadt, March

Bayrasy, P.; Burger, Michael; Dehning, C.; Kalmykov, I.; Speckert, Michael
Applications for MBS-FEM-coupling with MpCCI using automotive simulation as example
Kaiserslautern, March

Becker, Jürgen
Computer aided material engineering of porous transport layers used in PEFC
19th World Hydrogen Energy Conference, Toronto (CAN), June

Becker, Jürgen; Zamel, Nada; Wiegmann, Andreas
Computer based design study of porous tranport layers of PEFC
9th Symposium on Fuel Cell Modeling and Experimental Validation, Sursee (CH), April

Becker, U.; Simeon, Bernd
On Rosenbrock methods for singular singularly perturbed problems and their application to nearly incompressible materials
Halle, September

Becker,Jürgen; Cheng, Liping; Rief, Stefan; Wiegmann, Andreas
Simulation of Particle Filtration using GeoDict
11. Symposium Textile Filter, Chemnitz, March

Berger, Martin
Multicriteria Decentralized Decision Making in Collaborative Air Freight Forwarding
Informatikertag der Hochschule Mittweida, October

Bludau, Bastian; Velten, Sebastian; Küfer, Karl-Heinz
Multicriteria Rolling Wave Planning and Scheduling
25th European Conference on Operational Research, Vilnius (LT), July

Bouajjani, Ahmed; Derevenetc, Egor; Meyer, Roland
Enforcing robustness against Total Store Ordering
D-CON, Kaiserslautern, March

Buck, Marco; Iliev, Oleg; Andrä, Heiko
Domain decomposition preconditioners for the multiscale analysis of linear elastic composites
21st Int. Conf. on Domain Decomposition Methods, Rennes (F), June

Buck, Marco; Iliev, Oleg; Andrä, Heiko
Two-level domain decomposition preconditioners for multiphase elastic composites
25. Chemnitz FEM Symposium, September

Burger, Michael
Optimal Control of Delay-Differential-Algebraic Equations
Halle, September

Burger, Michael; Dreßler, Klaus; Speckert, Michael
Calculating Input Data for Multibody System Simulation by Solving an Inverse Control Problem
Enschede (NL), February

Cheng, Liping; Rief, Stefan; Wiegmann, Andreas
Simulation of Soot Filtration on the Nano-, Micro- and Mesoscale
11th World Filtration Congress, Graz (A), April

Cibis, Thomas; Marheineke, Nicole; Wegener, Raimund
Asymptotic modeling framework for fiber-flow interactions in a two-way coupling
The 17th European Conference on Mathematics for Industry 2012, Lund (S), July

De Kock, Johan; Korn, Ralf
Volatility Misspecification in Option Pricing Models
APMOD 2012, Paderborn, March

Desmettre, Sascha; Korn, Ralf; Ruckdeschel, Peter; Seifried, Frank
Robust Worst Case Optimal Investment
6th R/Rmetrics Meielisalp Workshop & Summer School 2012 on Computational Finance and Financial Engineering, Meielisalp-Thuner See (CH), June and Statistische Woche, Wien (A), September

Dillhöfer, Alexander; Rieder, Hans; Spies, Martin; Kreier, Peter
Einsatz der Phased-Array-Technik mit Matrix-Sensoren bei stark schallschwächenden Werkstoffen
DACH-Tagung 2012, Graz (A), September

Dobrovolskij, Dascha; Spies, Martin; Rieder, Hans;Dillhöfer, Alexander
Simulation of ultrasonic propagation considering attenuation in solid materials
Joint Workshop CMM - ITWM, Kaiserslautern, October

Dressler, Klaus
Reifenmodellierung in der Fahrzeugentwicklung
Essen, September

Dreyer, Alexander
Applying Boolean Gröbner Basis to Cryptography and Formal Verification
KTH, Stockholm (S), November

Dreyer, Alexander
Basics on Boolean Gröbner Basis and Algebraic SAT solving
KTH, Stockholm (S), November

Dreyer, Alexander
Fast Model-order Reduction for Mechatronic Systems
Challenge-Workshop MSO-Tools 2012 »Modeling, Simulation and Optimisation Tools«, TU Berlin, September

Eberle, Sarah; Ostermann, Isabel
3D-Modellierung des Wärmetransports in tiefen hydrothermalen Systemen
Geothermiekongress 2012, Karlsruhe, November

Escoda, Julie; Wirjadi, Oliver
Textile composites modeling based on Markov process
Joint Workshop CMM – ITWM, Kaiserslautern, October

Eulering, Georg; Ruckdeschel, Peter
Autokorrelationen im Marktpreisrisikomanagement
Arbeitskreis bei DSGV-Fachtagung Risikocontrolling, Berlin, December

Ewe, Hendrik; Küfer, Karl-Heinz; Plociennik, Kai; Schüle, Ingmar
Multicriterial Decision Support for Photovotaic Power Plant Design
25th European Conference on Operational Research, Vilnius (LT), July

Föhst, Sonja; Konerding, M. A.; Houdek, J. P.; Schladitz, Katja; Wagner, W.; Wirjadi, Oliver
Geometric modeling of lung growth in mice
Joint Workshop CMM - ITWM, Kaiserslautern, October

Galliani, Silvano
Getting depths with shading
Joint Workshop CMM - ITWM, Kaiserslautern, October

Gallrein, Axel; Bäcker, Manfred
CDTire: State-of-the-Art tire models for full vehicle simulation
Detroit (USA), May

Gallrein, Axel; Bäcker, Manfred
Spreading the application range of the Digital Road approach: New CDTire model developments
München, April

Gramsch, Simone
Mit Mathematik vom Kunststoff zur Alcantara-Couch
Universität Siegen, June

Grünewald, Daniel
The Fraunhofer GPI Programming Model – How it Works? Scalability & Failure Tolerance
ISC.12, Hamburg, June

Hack, M.; Hagestedt, B.; Weyh, Thorsten
New developments for improved fatigue prediction of welded joints
Kaiserslautern, March

Hauser, Matthias
Hierarchical Model-order Reduction for Robust Design of Parameter-varying Systems
International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design (SMACD), Sevilla (E), September

Horbenko, Nataliya; Kohl, Matthias; Ruckdeschel, Peter
New LD estimators for LOS
CFE-ERCIM 2012, Oviedo (E), Dezember

Horbenko, Nataliya; Kohl, Matthias; Ruckdeschel, Peter
"Bed at Risk" – How long must we stay robust(ly)?
Emeritierungskolloquium von Prof. Dr. Marazzi, Université de Lausanne (CH), November

Horbenko, Nataliya; Kohl, Matthias; Ruckdeschel, Peter; Otto, Gordon
Robust Extreme Value Statistics for Hospital Length of Stay
Kolloquium Universität Heidelberg, December

Horbenko, Nataliya; Ruckdeschel, Peter
Robust Operational Risk Quantification
Stochastiktage Mainz, March

Horbenko, Nataliya; Ruckdeschel, Peter; Bae, Taehan
Robust Quantile Regression with Application to Scaling of OpRisk Loss Data
Statistische Woche, Wien, September

Horbenko, Nataliya; Ruckdeschel, Peter; Bae, Taehan
Severity Scaling of Operational Losses
Bachelier 2012, Sydney, June

Hubel, Sebastian; Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Bamberg, Joachim; Hessert, Roland; Preikszas, Christine
Basic Investigations to Establish an Ultrasonic Stress Evaluation Technique for Aero Engine Materials
4th Internat. Symposium on NDT in Aerospace, Augsburg, November

Hubel, Sebastian; Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Hessert, Roland; Bamberg, Joachim; Preikszas, Christine
Grundlegende Untersuchungen zur Spannungsmessung mittels Ultraschall an Triebwerkswerkstoffen
DACH-Tagung 2012, Graz (A), September

Hübsch, Florian; Marheineke, Nicole; Wegener, Raimund
Efficient sampling of random fields for fiber-fluid interactions in isotropic turbulence.
17th European Conference on Mathematics for Industry 2012, Lund (S), July

Iliev, Oleg; Kabel, Matthias; Kirsch, Ralf; Lakdawala, Zahra; Toroshchin, Edward; Dedering, Michael
Mathematical modeling and numerical simulation of filter elements
ACHEMA Kongress 2012, Frankfurt, June

Iliev, Oleg; Latz, Arnulf; Schmidt, Sebastian; Zausch, Jochen; Zhang, Shiquan; Steiner, Konrad
On modeling and simulation of porous electrodes in Lithium-Ionen-Battery
4th International Conference on Porous Media of the International Society for Porous Media; Purdue University, West Lafayette (USA), May

Iliev, Oleg; Lazarov, Raytcho; Willems, Jörg
On upscaling heat conductivity for a class of industrial problems
Multi-scale computational methods für solids and fluids, ECCOMAS Thematic Conference, Paris (F), November

Iliev, Oleg; Zemitis Aivars, Gornak Tatjana, Steiner Konrad
CoPool – a tool for the liquid and heat simulation in containment
German CFD network meeting, Garching, March und 4th COCOSYS workshop Garching, March

Jablonski, Andreas; Moghiseh, Ali
Visual Programming for Image Processing
IPOL 2012 Meeting on Image Processing Libraries, Paris (F), June

Kabel, Matthias; Andrä, Heiko
Fast Numerical Computation of Precise Bounds of Effective Elastic Moduli
25th International Workshop Research in Mechanics of Composites, Bad Herrenalb, December

Kabel, Matthias; Andrä, Heiko
Optimization of microstructured multilayer acoustic trims
NAFEMS Seminar »Generation and propagation of sound in solids and fluids - Modern analysis methods in acoustics«, Wiesbaden, November

Kabel, Matthias; Andrä, Heiko
Predicting effective elastic properties with FeelMath-VOX Part I
GeoDict User Meeting 2012, Kaiserslautern, October

Kabel, Matthias; Ändrä, Heiko
Fast numerical computation of the effective mechanical properties of materials with complex microstructure
Seminarvortrag Fraunhofer IWM, Freiburg, November

Kang, S. H.; Shafei, Behrang; Steidl, G.
Supervised multi-class segmentation using p-Laplacians and RKHS methods
Joint Workshop CMM - ITWM, Kaiserslautern, October

Kleer, Michael; Hermanns, Oliver; Müller, S.
Konzeption eines Fahrsimulators für die Nutzfahrzeugindustrie auf Basis eines Industrieroboters
Kaiserslautern, March

Kleer, Michael; Hermanns, Oliver; Müller, S.; Dreßler, Klaus
Driving simulations for commercial vehicles - A technical overview of a robot based approach
Paris (F), September

Klein, Matthias
myPowerGrid – Speicher für grüne Energie
B-Beirat der Pfalzwerke AG, Neuhofen, October

Knaf, Hagen
Ein innovatives Konzept für die Aufzeichnung von Prozessdaten: Analytische Datenbank mit eingebetteten Data Mining Komponenten
Fachausschüsse Glasschmelztechnologie und Umweltschutz der Deutschen glastechnischen Gesellschaft, Fraunhofer ISC, Würzburg, September

Korn, Ralf
Advances in Financial Mathematics with Applications to Engineering
University of Texas, Austin (USA), September

Korn, Ralf
Die Zukunft der Zinsgarantie in der Lebensversicherung – Wissenschaftliche Sicht
Akademietag der DAA, Köln, November

Korn, Ralf
Optimal Portfolios for an Investor with a Benchmark
CKFA-Meeting, Kaiserslautern, March

Korn, Ralf
Optimale Portfolios – Bekanntes und Neues
Fakultätskolloquium Mathematik, Universität Magdeburg, June

Korn, Ralf
Recent Advances in Option Pricing via Binomial Trees
Computational Stochastics Workshop, Annweiler, March

Korn, Ralf
The Adjoint Approach for calculating Greeks of Bermudan Swaptions
DMV-Tagung, Saarbrücken, September

Korn, Ralf
The Future of the Interest Rate Guarantee in German Life Insurance
10th Anniversary IAM-Meeting, METU Ankara (TR), October und 1. EAJ-Meeting, Univ. Lausanne (CH), September

Korn, Ralf
Was kosten die Garantien?
2. FaRis und DAV-Symposium, Köln, May

Korn, Ralf
Wie finde ich die beste Wohnung in London?
Tag der Mathematik, TU Kaiserslautern, June

Korn, Ralf
Wie viel Zins braucht die Praxis?
Versicherungsmathematisches Kolloquium, LMU München, May

Küfer, Karl-Heinz
What and how can we learn from Pareto fronts and sets?
Dagstuhl Seminar »Learning in Multiobjective Optimization«, Dagstuhl, January

Küfer, Karl-Heinz; Gramsch, Simone
Fraunhofer ITWM - das Institut für Industriemathematik in Kaiserslautern
DMV-Jahrestagung 2012, Saarbrücken, September

Lakdawala, Zahra; Iliev, Oleg, Kirsch, Ralf
An overview on filtration activities
Bologna (I), October

Lakdawala, Zahra; Iliev, Oleg, Kirsch, Ralf
Filter element simulations using FiltEST based on GeoDict results
Kaiserslautern, October

Lakdawala, Zahra; Ströbener, Katrin; Jarosch, Jermeias; Klein, Peter
Membrane performance testing and modelling: Mesoscopic level simulation
Nanopur Meeting, Bologna (I), Oktober

Lang, Holger; Linn, Joachim
On the Effect of the Discretisation Scheme on the Eigenfrequencies and Modes of Shear Flexible Rods
Stuttgart, May

Lang, Patrick
Von der Datenanalyse zur Biomarkeridentifikation
6. Biotech-Tag, Fachhochschule Bingen, April

Latz, Arnulf; Zausch, Jochen
Full 3D Modeling and Simulation of Li ion Batteries with BEST
Advanced Automotive Battery Conference Europe, Mainz, June

Latz, Arnulf; Zausch, Jochen
Thermodynamically derived model and simulation of intercalation for a microscopic transport model of Li-ion batteries
63rd Annual Meeting of the International Society of Electrochemistry, Prag (CZ), August

Leithäuser, Neele; Krumke, Sven O.; Merkert, Maximilian
Approximating Infeasible 2VPI-Systems
38th International Workshop on Graph Theoretic Concepts in Computer Science , Ramat Rachel, Jerusalem (IL), June

Leithäuser, Neele; Schüle Ingmar; Krumke, Sven O.
Optimierte Abstimmung der Umsteigebeziehungen im ungetakteten ÖPNV unter Berücksichtigung der Umlaufplanung
Multikonferenz der Wirtschaftsinformatik, Braunschweig, March

Lemke, Tatjana
Inference in CAR models driven by alpha-stable Levy processes
SMC workshop, Coventry (GB), September

Lemke, Tatjana
Linear Gaussian computations for near-exact Bayesian MC inference in skewed alpha-stable time series models
International Conference on Acoustics, Speech, and Signal Processing, Kyoto (J), March

Lemke, Tatjana
Markov chain Monte Carlo methods
PhD Seminar, TU Kaiserslautern, November

Lemke, Tatjana
Monte Carlo inference for alpha-stable processes
Seminar, Cambridge (GB), April, TU KL-TUM Research Seminar, Lambrecht, August und PhD Seminar, TU Kaiserslautern, September

Liebscher, André; Redenbach, Claudia
Modelling the local strut thickness of open foams based on 3D image data
Joint Workshop CMM - ITWM, Kaiserslautern, October

Linden, Sven; Wiegmann, Andreas; Hagen, Hans
The LIR Space Partitioning System applied to Cartesian Grids
8th International Conference on Mathematical Methods for Curves and Surfaces, Oslo (N), June

Linn, Joachim
Discrete models for flexible structures – Nonlinear structural mechanics meets Discrete Differential Geometry
17th European Conference on Mathematics for Industry, Lund (S), July

Linn, Joachim
Viscoelastic Cosserat rods of Kelvin-Voigt and generalized Maxwell type
Erlangen, September

Linn, Joachim; Lang, Holger; Tuganov, A.
Geometrically exact Cosserat rods with Kelvin–Voigt type viscous damping
Stuttgart, May

Lorenz, Maike; Marheineke, Nicole; Wegener, Raimund
On die swell simulations in spinning processes with a stationary one-dimensional upper convected Maxwell model
17th European Conference on Mathematics for Industry, Lund (S), July

Machado, Rui
Parallel Constraint-based Local Search - Experiments with Adaptive Search and GPI
NII Shonan Meeting on Parallel Methods for Constraint Solving and Combinatorial Optimization, Shonan (J), May

Malten, Rebekka
Blick über den Tellerrand der klassischen Oberflächeninspektion
Vision Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung« am Fraunhofer IOSB, Karlsruhe, November

Malten, Rebekka
ToolIP – A graphical Tool for Image Processing
15. SpectroNet Collaboration Forum, Stemmer Imaging, Puchheim, Dezember

Malten, Rebekka
ToolIP–Tool for Image Processing
IZFP Saarbrücken, January

Maringer, Johannes; Klar, Axel; Wegener, Raimund
Modeling of nonwoven structures generated by fiber laydown as 3d stochastical processes

The 17th European Conference on Mathematics for Industry, Lund (S), July und DMV-Jahrestagung 2012, Saarbrücken, September

Mohrbacher, Christian
FhGFS – Parallel file system performance at the maximum
Supercomputing-12, Salt Lake City (USA), November

Müller, Lilli; Bitsch, Gerd
Simulationsgestütztes Monitoring der Betriebsbeanspruchung
Baden-Baden, November

Müller, Lilli; Bitsch, Gerd; Schindler, C.
Online Condition Monitoring based on Real-Time Multibody System Simulation
Kaiserslautern, March

Neunzert, Helmut
Forschung und Wissenstransfer – wie eine Universität eine Region verändert
Pfälzische Gesellschaft für zur Förderung der Wissenschaften, Kaiserslautern, October

Neunzert, Helmut
Mathematics – a modern key technology
TU Hugo Steinhaus Center, Wroclaw (PL), October

Neunzert, Helmut
Mathematik ist (fast) überall
MINT-EC, Berlin, January

Neunzert, Helmut
Mathematische Modellierung – ein »Curriculum Vitae«
Tagung »Geschichte und Modellierung«, Jena, February

Neunzert, Helmut
Stufen
Verabschiedung Prof. Trottenberg, Bonn, May

Neunzert, Helmut
The early days of ECMI
17th European Conference on Mathematics for Industry, Lund (S), July

Neunzert, Helmut
What is industrial mathematics and why should we do it?
TU Hugo Steinhaus Center, Wroclaw (PL), October

Neunzert, Helmut
Wie wirklich ist die Wirklichkeit?
Festveranstaltung »50 Jahre Rotary Club«, Idar-Oberstein, October

Nickel, Stefan
A multi-stage stochastic supply network design problem with financial decisions and risk management
Tagung Coral, Benicassim Castellón (S), May

Nickel, Stefan
How to publish in COR – Ask the editor
Convex nondifferentiable optimization and resource allocation, Zinal (CH), September

Nickel, Stefan
Operations Research in Health Care Logistics
YAEM Jahrestagung, Istanbul (TR), June

Nowak, Dimitri; Küfer, Karl-Heinz
Solving uniform coverage problems in industrial production with Abel Inversion
3rd International Conference of Engineering Optimization EngOpt 2012, Rio de Janeiro (BR), July

Nowak, Uwe; Bortz, Michael; Küfer, Karl-Heinz
Efficient Approximation of Pareto-Frontiers with Application to Chemical Process-Optimization
25th European Conference on Operational Research, Vilnius (LT), July

Obermayr, Martin; Elbel, G.
Simulation of the Soil-Tool Interaction for Hydraulic Excavators
Kaiserslautern, March

Orlik, Julia
Homogenization via unfolding in periodic elasticity with contact on closed and open cracks
GAMM-Microstructures, Universität Essen-Duisburg, January und International Workshop on Evolution problems in damage, plasticity and fracture: mathematical models and numerical analysis, University of Udine (I), September

Orlik, Julia
Homogenization via unfolding in periodic elasticity with contact on oscillating interface
GAMM-Jahrestagung, TU Darmstadt, March

Orlik, Julia
Simulation of textiles based on the asymptotic homogenization and dimension reduction
25th International Workshop Research in Mechanics of Composites, Bad Herrenalb, December

Orlik, Julia
Simulation of woven, knitted and spacer fabrics based on multi-scale models with large deformations
Fourth world conference on 3D fabrics and their applications, RWTH Aachen, September

Orth, Thomas; Schmitte, Till; Spies, Martin; Rieder, Hans; Kersting, Th.
Simulation und Validierung eines optimierten Phased-Array-Verfahrens zur Querfehlerprüfung von SAWL-Schweißnähten in ferritischen Rohren
DACH-Tagung 2012, Graz (A), September

Ostermann, Isabel
STRING – Ein Visualisierungstool für beliebige Geschwindigkeitsfelder
10. SPRING Conference and User's Meeting 2012, Witten, December

Pfreundt, Franz-Josef
A parallel file system made in Germany
IEEE Conference on Massive Data Storage, Pacific Grove (USA), April

Pfreundt, Franz-Josef
Big Data and Cloud File Systems
ISC Cloud'12, Mannheim, September

Pfreundt, Franz-Josef
FhGFS–HSM–and tiered storage
11th HLRS/hww- Workshop on Scalable Global Parallel File Systems, Stuttgart, May

Pfreundt, Franz-Josef
Interaktive fotorealistische Produktvisualisierung am Beispiel eines Automobilherstellers
Hewlett Packard, Frankfurt, March

Pfreundt, Franz-Josef
Pros & Cons of File Systems for HPC Systems
ISC.12, Hamburg, June

Plociennik, Kai
A probabilistic PTAS for shortest common superstring
21st International Symposium on Mathematical Programming, Berlin, August

Prill, Torben
Morphological segmentation of FIB-SEM data
Joint Workshop CMM - ITWM, Kaiserslautern, October

Prill, Torben
Segmentation of FIB/SEM Data
7th Int. Conf. Stereology, Spatial Statistics and Stochastic Geometry, Prag (CZ), June

Prill, Torben
Simulation of FIB-SEM Images for Segmentation of Porous Microstructures
International Conference on 3D Materials Science 2012, Seven Spring (USA), July

Pupashenko, Daria; Franke, Jürgen; Ruf, Nikolaus; Ruckdeschel, Peter
Robust Kalman smoothing for dynamic vehicle data
Workshop Robust Methods for Dependent Data, Witten, February

Pupashenko, Daria; Ruckdeschel, Peter; Spangl, Bernhard
RobKalman – a package for robust filtering
6th R/Rmetrics Meielisalp Workshop & Summer School 2012 on Computational Finance and Financial Engineering, Meielisalp (CH), June

Pupashenko, Daria; Ruckdeschel, Peter; Spangl, Bernhard
Robust Multivariate extended Kalman Filtering and its implementation in R
TU München, TU Kaiserslautern Seminar, August and Statistische Woche, Wien, September

Rahn, Mirko
The Limitations of MPI
ISC.12, Hamburg Juni

Rauhut, Markus; Spies, Martin; Taeubner, Kai
Auslegung und Performance von berührungslosen Verfahren zur Inline-Oberflächeninspektion
DACH-Tagung 2012, Graz (A), September

Rieder, Hans; Dillhöfer, Alexander; Spies, Martin
ZfP in der maritimen Industrie – zwischen Ökonomie, Human Factor und Ökologie
DACH-Tagung 2012, Graz (A), September

Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Rieder, Isabell; Holstein, Ralf
Präsentation von E-Learning Modulen für den Kurs UT1 der DGZfP
DACH-Tagung 2012, Graz (A), September

Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Rieder, Isabell; Holstein, Ralf
Umsetzung eines Blended Learning Konzepts für die ZfP am Beispiel eines Ultraschallkursus
DACH-Tagung 2012, Graz (A), September

Rief, Stefan; Glatt, Erik; Wiegmann, Andreas; Kabel, Mathias; Andrä, Heiko
Deformation and the Change of Filtration Properties of Weaves – A Computational Approach
World Filtration Congress, Graz (A), April

Ruckdeschel, Peter
Minmax Entropy – Where did all the information go?
Workshop Cambridge-Kaiserslautern Finance Alliance, March

Ruckdeschel, Peter; Erlwein-Sayer, Christina
Robust HMM-based Online Filtering for Investment Strategies
Stochastiktage Mainz, Mainz, March

Ruckdeschel, Peter; Erlwein-Sayer, Christina
Robustification of HMM-Based Investment Strategies for Asset Allocation
APMOD 2012, Paderborn, March

Ruckdeschel, Peter; Spangl, Bernhard; Erlwein-Sayer, Christina
Optimally-Robust Filtering
Mathematisches Kolloquium Universität Bayreuth, February und Workshop Robust Methods for Dependent Data, Witten, February

Sayer, Tilman; Ruckdeschel, Peter; Szimayer Alexander
Pricing employee stock options in the Heston model: a close look on incorporating correlation
APMOD 2012, Paderborn, March

Scherrer, Alexander
Mathematische Methoden in der Therapieplanung
Science-Alliance, Diemerstein, November

Schladitz, Katja
µCT von Papier
PTS-Seminar »Moderne analytische Methoden in der Papiertechnik«, Heidenau, October

Schladitz, Katja
3D-Bildanalyse der Mikrostruktur komplexer Materialien
Vision-Technologietag, Jena, October

Schladitz, Katja
Quantitative 3d analysis of microstructures
DocMASE Summer School, Saarbrücken, August

Schladitz, Katja
Quantitative Mikrostrukturanalyse anhand von 3D Bilddaten
DGM-Fachausschuss Zellulare Werkstoffe, Heuchelheim, April

Schladitz, Katja
Simulation von FIB-REM-Tomografien poröser Mikrostrukturen
DGM-Arbeitskreis Quantitative 3D-Mikroskopie von Oberflächen, Karlsruhe, April

Schmidt, Sebastian
CoRheoS – a framework for fast and flexible implementation of industrial, linear and nonlinear PDE solvers
PDESoft, Münster, June

Schmidt, Sebastian; Latz, Arnulf; Jäger, Magnus
Simulation of complex microfluidics for biotechnology applications
ACHEMA, Bioprocesses - Measurement and modelling, Frankfurt, June

Schmidt, Sebastian; Niedziela, Dariusz; Zausch, Jochen; Latz, Arnulf
CoRheoS: Multiphysics Solver Framework and Simulation Infrastructure for Complex Rheologies
NAFEMS Multiphysics, Frankfurt, October

Schmitte, Till; Orth, Thomas; Spies, Martin; Kersting, Thomas
Schallfelder von Phased-Array Prüfköpfen: Vergleich von photoelastischen Messungen und Simulationen
DACH-Tagung 2012, Graz (A), September

Schröder, Michael; Guenster, Lucienne
The Impact of Navigational Services on Public Transportation Networks
International Annual Conference of the German OR Society 2012, Hannover, September

Schüle, Ingmar
Perspectives of PV in Germany and Europe
IASS International Workshop "Renewable Energy Perspectives in Latin America in the international context", Potsdam, October

Schüle, Ingmar; Ewe, Hendrik; Plociennik, Kai
Multi-Objective Planning of Large-Scale Photovoltaic Power Plants
International Annual Conference of the German OR Society 2012, Hannover, September

Schulze, M.; Dietz, S.; Tuganov, Lang, Holger; Linn, Joachim
Integration of nonlinear models of flexible body deformation in Multibody System Dynamics
Stuttgart, May

Shafei, Behrang
Supervised and Transductive Multi-Class Segmentation Using p-Laplacians and RKHS Methods
Workshop on Advances in Mathematical Image Processing, Göttingen, September

Spahn, Johannes; Andrä, Heiko; Kabel, Matthias; Müller, Ralf
A Multiscale Damage Model for Composite Materials an Numerical Computations by Using a FFT-Based Method
8th European Solid Mechanics Conference, Graz (A), July

Spahn, Johannes; Andrä, Heiko; Müller, Ralf
A Multiscale Damage Model for Fiber-Reinforced Polymer (FRP) Materials
LTM Skiseminar 2012, Val d'Illiez (CH), March

Spahn, Johannes; Andrä, Heiko; Staub, Sarah; Kabel, Matthias; Müller, Ralf
A Micromechanical Damage Model for Fiber-Reinforced Polymer (FRP) Materials
11th GAMM-Seminar on Microstructures, Essen, January

Spies, Martin
3D-Schallfeldsimulation in Echtzeit und Modell-basierte POD-Bestimmung – Aktuelle Entwicklungen in der simulationsunterstützten Ultraschallprüfung
Seminar »Grundlagen und Anwendungen der zerstörungsfreien Prüfverfahren«, Vst.-Nr. 65074, Universität des Saarlandes, Saarbrücken, December

Spies, Martin
Verbesserung der Fehlerauffindwahrscheinlichkeit (POD) durch den Einsatz von Modellierungs- und Bildgebungsalgorithmen am Beispiel von schwer prüfbaren Schiffspropellerwerkstoffen
DGZfP-Arbeitskreis Stuttgart, June

Spies, Martin
Zerstörungsfreie Prüfung mit Ultraschall und Tomographie an schwer prüfbaren Werkstoffen
Kolloquium Maschinenbau, Duale Hochschule Mannheim, January

Spies, Martin, Jablonski, Andreas; Rauhut, Markus; Rieder, Hans
Erweiterte Modelle für die ZfP zur Ermittlung der Auffindwahrscheinlichkeit (POD) von Oberflächen- und Volumenfehlern
DACH-Tagung 2012, Graz (A), September

Spies, Martin, Rieder, Hans, Dillhöfer, Alexander, Schmitz, Volker, Müller, Wolfgang
Synthetic aperture focusing and time-of-flight diffraction ultrasonic imaging – past and present
18th World Conference on NDT, Durban (ZA), April

Spies, Martin, Rieder, Hans; Dillhöfer, Alexander
Modell-basierte Bestimmung der Auffindwahrscheinlichkeit (POD) von Volumenfehlern in schwerprüfbaren Bauteilen
DACH-Tagung 2012, Graz (A), September

Spies, Martin; Dillhöfer, Alexander; Rieder, Hans; Dobrovolskij, Dascha
Real-time 3D-Simulation Tool for Ultrasonic Transducers Used in Aeroengine Component Inspections
4th International Symposium on NDT in Aerospace, Augsburg, November

Stahl, Dominik
Parameterization of all (1,2,3)-generalized inverses with an application to scattered data approximation
GAMM-Jahrestagung, TU-Darmstadt, March

Steidel, Stefan
Gröbner Bases of Symmetric Ideals
St. Petersburg (RUS), April

Steidel, Stefan
Standard Bases
Lahore (PK), February

Steiner, Konrad
Image Analysis of Microstructures of Industrial Materials and Computation of Effective Properties of Composite Materials based on their microstructure
KAUST SRI Center on Numerical Porous Media; Jeddah (KSA), June

Steiner, Konrad
Simulations supporting the design and selection of filter media
KAUST SRI Center on Numerical Porous Media; Jeddah (KSA), June

Stephani, Henrike
Including Spatial Similarities into Hierarchical Clustering of Hyperspectral Terahertz Images
SIAM Conference on Imaging Science (IS12), Philadelphia (USA), May

Stephani, Henrike
Typischer Aufbau eines Online-Oberflächeninspektionssystems
Vision Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung«, Fraunhofer IOSB, Karlsruhe, November

Süss, Philipp
Multicriteria Optimization of Therapy Planning for Cancer Diseases
Beyond basic science – Mathematics today, Bialka Tatrzanska (PL), February

Taffe, Alexander, Spies, Martin, Recknagel, Jörg
Schulung zur zuverlässigen Ortung von Bewehrung in Stahlbetonbauteilen von Kraftwerken
DGZfP Fachtagung Bauwerksdiagnose, Berlin, February

Trinkaus, Hans L.
Multi Criteria Decision Support in Real-Time. Integration of Project, Process and Knowledge Management
21st International Symposium on Mathematical Programming, TU Berlin, August

Trinkaus, Hans L.
Talk, "touch", tell – intelligent tablets assist health care consultations and services
International Conference on Communication in Healthcare, St. Andrews University, St. Andrews (GB), September

Vecchio, Irene
Fitting Laguerre Tessellations to the Microstructure of Cellular Materials
International Conference on 3D Materials Science 2012, Seven Spring (USA), July

Vecchio, Irene
Laguerre tessellations: fitting a model to rigid closed-cell polymer foams
CellMat 2012, Dresden, November

Vecchio, Irene
Modeling rigid closed-cell foams by random Laguerre tessellations
7th Int. Conf. Stereology, Spatial Statistics and Stochastic Geometry, Prag (CZ), June

Vecchio, Irene; Schladitz, Katja; Redenbach, Claudia
Fitting random Laguerre tessellations to the microstructure of rigid closed-cell foam
Joint Workshop CMM - ITWM, Kaiserslautern, October

Velasco-Forero, Santiago; Angulo, Jesus
On non-local mathematical morphology
Joint Workshop CMM - ITWM, Kaiserslautern, October

Wagner, Andreas
Electricity Pricing in a Market with Renewables
International Ruhr Energy Conference 2012, Essen, March

Wagner, Andreas
Residual Demand Modelling and an Integrated Spot/Forward Model
Workshop on Electricity Price Modelling (EdF), Paris (F), December

Wagner, Andreas
Residual Demand Modelling and Application to Electricity Pricing
12th IAEE European Energy Conference, Venedig (I), September; TU Kaiserslautern - RWE Workshop, Kaiserslautern, September und Energy Finance Conference 2012, Trondheim (N), October

Weber, Dietmar; Obermayr, Martin; Bäcker, Manfred
Deformierbarer Boden in MKS-Reifensimulationen
Karlsruhe, November

Wegener, Raimund
Engineering stochastischer Prozesse
Evaluierung des Innovationszentrums Applied System Modeling, Kaiserslautern, March

Weibel, Thomas
Contrast-enhancing seam detection and blending using graph cuts
21st International Conference on Pattern Recognition (ICPR), Tsukuba (J), November

Weigel, N.; Sing, V.; Bitsch, Gerd; Streit, Anja; Dreßler, Klaus; Grieshofer, O.; Kaltenbrunner, M.
Ableitung von Konzepten und Lastdaten für vereinfachte Betriebsfestigkeitserprobungen mittels Mehrkörpersimulation
Kaiserslautern, March

Weischedel, Clarisse; Tuganov, A.; Hermansson, T.; Linn, Joachim; Max, W.
Construction of discrete shell models by geometric finite differences
Stuttgart, May

Wirjadi, Oliver
Algorithms for Computing Volume-Weighted Fiber Orientation Tensors
7th Int. Conf. Stereology, Spatial Statistics and Stochastic Geometry, Prag (CZ), June

Zangmeister, Tobias; Andrä, Heiko; Müller, Ralf
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LMS-ITWM Kooperationstreffen, Kaiserslautern, June

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Präsentation von E-Learning Modulen für den Kursus UT1 der DGZfP
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Arne, Walter
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Doctoral thesis, Universität Kassel, Dept. of Mathematics and Sciences

Beck, Anastasia
Das KMV-Modell als Erweiterung der Firmenwertmodells von Merton
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Becker, Urs
Efficient time integration and nonlinear model reduction for incompressible hyperelastic materials
Doctoral thesis, University of Kaiserslautern

Biedert, Tim
FPM Postprocessing: Real-Time Ray Tracing of Point Set Surfaces in OptiX
Bachelor thesis, University of Kaiserslautern, Dept. of Computer Sciences

Blauth, Marco
Detektion and Klassifikation von Verkehrszeichen
Bachelor thesis, University of Applied Sciences Kaiserslautern, Dept. of Applied Engineering Sciences

Bossong, Heiko
Charakterisierung and Simulation des nichtlinearen Verhaltens eingebetteter piezoelektrischer Keramiken
Doctoral thesis, Rheinisch-Westfälische Technische Hochschule Aachen

Cavar, Katarina
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Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Filipyeva, Yauheniya
Arbitrage-free Interpolation of Volatility Surfaces
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Grimm, Stefanie
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Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Grün, Sarah
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Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Günster, Laura
Operational and Tactical Models and Algorithms for Optimisation of Patient Transport in Hospitals
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Günster, Lucienne
Models and Algorithms for Customer-Oriented Dynamic Schedule Synchronization in Regional Public Transport Networks
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Harutyunyan, Mané
Mathematical Modeling and Numerical Simulation of Fiber-Reinforced Materials
Diploma thesis, University of Kaiserslautern

Horsky, Roman
Barrier Option Pricing and CPPI-Optimization
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Keth, Sandra
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Master thesis, University of Kaiserslautern, Dept. of Mathematics

Klein, Christian
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Bachelor thesis, University of Applied Sciences Kaiserslautern, Location Zweibrücken

Klug, Alena
Path Planning and Table Pattern Design in Photovoltaic Power Stations
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Koch, Johannes
Vergleich und Analyse verschiedener Konzepte zur modellbasierten prädiktiven Regelung eines Haushaltskühlschranks
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Kochendörfer, Alexandra
Maximizing the Asymptotic Growth Rate under Fixed and Proportional Transaction Costs in a Financial Market with Jumps
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Kontak, Max
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Bachelor thesis, University Siegen, Natural Sciences and Technology Faculty, Department Mathematik

Kovtaniuk, Aleksandra
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Master thesis, University of Kaiserslautern, Dept. of Mathematics

Koyoeu, Judith
Robust Regression in Generalized Linear Models
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Krengel, Annette
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Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Kronenberger, Markus
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Bachelor thesis, University of Kaiserslautern, Dept. of Computer Sciences

Kronsbein, Cornelia
On selected efficient numerical methods for multiscale problems with stochastic coefficients
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Krüger, Jens
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Kruglova, Ekatarina
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Master thesis, University of Kaiserslautern

Leichner, A.
Parameteridentifikation am Beispiel von analytischen Reifenmodellen
Bachelor thesis, University of Kaiserslautern

Leithäuser, Neele
Algorithms and Complexity of Timetable Synchronization and Vehicle Scheduling Problems in an Integrated Approach
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Linn, Dominik
Simulation und Analyse der durch Rotationssprühen erzeugten Tropfenbahnen und Flächenverteilung
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Lörwald, Bernd
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Bachelor thesis, DHBW Mannheim, Applied computer science

Ludwig, C.
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Bachelor thesis, University of Kaiserslautern

Marky, Karola
Algorithmische Prozessanalyse von Spunbondprozessen
Bachelor thesis, University of Kaiserslautern, Dept. of Computer Sciences

Massini, Eugen
A small comparison of variable selection methods on linear regression models
Master thesis, University of Kaiserslautern, Dept. of Mathematics

Meyer, Maximilian
Numerische Simulation interagierender Filamente
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Moll, Lilli
Optimal Placement Strategies for Block Planning in Photovoltaic Plants
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Müller, Lilli
Mehrkörpermodell-basiertes Online Monitoring der Betriebsbeanspruchung am Beispiel eines Nutzfahrzeug-Demonstrators
Doctoral thesis, University of Kaiserslautern

Müller, Yvonne
Adjusting Overload Capacity in Production Planning
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Obermaier, Harald
Feature based visualization of gridless vector fields
Diploma thesis, University of Kaiserslautern, Dept. of Computer Sciences

Pfeiffer, Laura
Modellierung, Simulation und Optimierung der Filamentverteilung und der Prozessparameter beim Rotationsspinnen
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Pfeiffer, Nicole
Optimization of Decomposed Intralogistics Processes at Air Cargo Transshipment Centers
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Pfirsching, Marion
Die Methode von Vladimir Oliker, Theorie und Implementierung
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Plucik, Michael
A Study on the Efficiency of Direct and Iterative Solvers for Finite Element and Finite Volume Grids via Grid Adaption, Parallelization and Preconditioning and its Application to Press Nips of Paper Machines
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Printsypar, Galina
Mathematical Modeling and Simulation of Two-Phase Flow in Porous Media with Application to the Pressing Section of a Paper Machine
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Rauscher, Sonja
Anisotrope Punktprozesse
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Sayer, Tilman
Valuation of American-style derivatives within the stochastic volatility model of Heston
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Schlachter, Anna-Lena
Segmentierung und statistische Analyse des Wandsystems in Schäumen
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Schmidtmann, Birte
Transfer of therapeutic agents, coupling free flow area and porous media
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Schneider, Linda-Sophia
Das Black-Litterman-Modell
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Schöttle, Florian
Numerische Homogenisierung der elastischen Eigenschaften faserverstärkter Polymerwerkstoffe
Bachelor thesis, Karlsruhe Institute of Technology, Dept. of Mechanical Engineering

Schüle, Laura
Das Erwartungswert-Varianz-Modell, CAPM und die Efficient Frontier
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

Schwarz, Gaby
Automatische bildanalytische Zellrekonstruktion für PMI-Hartschäume
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Schwientek, Jan
Modellierung und Lösung parametrischer Packungsprobleme mittels semi-infiniter Optimierung
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Stech, Frederik
Bilderkennung und Klassifizierung von Hirntumorzellen anhand medizinischer Daten
Diploma thesis, University of Applied Sciences Kaiserslautern, Dept. of Applied Engineering Sciences

Steidel, Stephan
Parallel modular computation in commutative algebra
Doctoral thesis, University of Kaiserslautern

Stephani, Henrike
Automatic Segmentation and Clustering of Spectral Terahertz Data
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics and Johannes-Kepler-Universität Linz, Dept. of Mathematics

Tabatschnik, Igor
Analyse und Modellierung von Prozessen als Bestandteil eines Geschäftsmodells für Pflegedienstleistungen
Bachelor thesis, University of Applied Sciences Kaiserslautern, Location Zweibrücken

Theresa Friedrich
Modellierung und Simulation von Filament-Spinnprozessen und Optimierung der Düsenanordnung
Bachelor thesis, Universität Kassel, Dept. of Mathematics and Sciences

Weischedel, Clarisse
A discrete geometric view on shear-deformable shell models
Doctoral thesis, University Göttingen

Welke, Richard
Mehrkriterielle Optimierung chemischer Prozesse
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Zeiler, Berta
Elliott's Filter-Algorithm For Hidden Markov Models With Correlated Observations
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Zemerli, Clement
Continuum mechanical modelling of granular systems
Doctoral thesis, University of Kaiserslautern, Dept. of Mechanical and Process Engineering

Zwiesler, Julia
Modellierung, Simulation und Optimierung der Fadenkreuzungsstruktur bei einem Rotationskopf
Bachelor thesis, University of Kaiserslautern, Dept. of Mathematics

PARTICIPATION ON FAIRS AND CONFERENCES

ACHEMA 2012
Frankfurt, June, Exhibitor, Lecture, Poster

Advanced Automotive Battery Conference Europe
Mainz, June, Lecture

AFS Annual Conference
Boca Raton (USA), June, Exhibitor, Lecture

54th Annual Meeting of the American Society for Radiation Oncology ASTRO 2012
Boston (USA), October, Poster

63rd Annual Meeting of the International Society of Electrochemistry
Prag (CZ), August, Lecture, Poster

APMOD Conference
Paderborn, March, Lecture

Beyond Basic Science – Mathematics Today
Białka Tatrzańska (PL), January, Lecture

48. Bildverarbeitungsforum »Bildgewinnung und -verarbeitung quer durch das elektromagnetische Spektrum«
Heidelberg, March

49. Bildverarbeitungsforum »Kameranetzwerke«
Langmeil, July

50. Bildverarbeitungsforum »Panta rhei – Bildanalyse von Strömung, Bewegung und Ereignissen«
Karlsruhe, October

6. Biotech-Tag: Biotechnologie-Schlüssel für Chemie, Medizin, Pharma
Bingen, April, Exhibitor, Lecture

CCG – Tyre Models in Vehicle Dynamics: Theory and Application
Wien (A), September

CeBit
Hannover, March, Exhibitor

CellMat 2012
Dresden, November, Lecture

CFE-ERCIM 2012
Oviedo (E), December, Lecture

Challenge-Workshop »Modeling, Simulation and Optimisation Tools« 2012
Berlin, September, Lecture

2nd Commercial Vehicle Technology Symposium
Kaiserslautern, March, Exhibitor, Lecture

Composites Europe 2012
Düsseldorf, October, Exhibitor

Computational Stochastics Workshop
Annweiler, March, Lecture

Conference in Energy Finance at WPI
Wien (A), September

Control 2012
Stuttgart, May, Exhibitor

CVC-Jahrestagung
Zweibrücken, November, Exhibitor

DAA-Akademietag
Köln, November, Lecture

DACH-Tagung 2012
Graz (A), September, Lecture, Poster

Dagstuhl Seminar "Learning in Multiobjective Optimization"
Wadern, January

Das Virtuelle Nutzfahrzeug
Mannheim, November

Deutschsprachige NAFEMS Konferenz
Bamberg, May

DGZfP Fachtagung Bauwerksdiagnose
Berlin, February, Lecture

DMV-Tagung
Saarbrücken, September, Exhibitor, Lecture

DSGV-Fachtagung Risikocontrolling
Berlin, December, Lecture

DVM-Tagung: Werkstoffe und Fügeverfahren – Neue Herausforderungen für die Betriebsfestigkeit
Paderborn, October, Exhibitor

EAGE 2012
Kopenhagen (DK), June, Exhibitor

ECCS'12
Brüssel (B), September

8th International Conference on Mathematical Methods for Curves and Surfaces
Oslo (N), June, Lecture

Embedded World 2012 Conference
Nürnberg, February

Energy Finance Conference 2012
Trondheim (N), October, Lecture

EU PVSEC – PV Solar Energy Conference and Exhibition
Frankfurt, September

European Actuarial Journal Conference
Lausanne (CH), September, Lecture

25th European Conference on Operational Research
Vilnius (LT), July, Lecture

8th European Solid Mechanics Conference
Graz (A), July, Lecture

FaRis und DAV-Symposium
Köln, May, Lecture

f-cell/battery+storage
Stuttgart, October, Exhibitor, Lecture

Firmenkontaktmesse »Treffpunkt«
Kaiserslautern, May, Exhibitor, Lecture

Fraunhofer Vision-Technologietag 2012
Jena, October, Lecture

GAMM-Jahrestagung
Darmstadt, March, Lecture

11th GAMM-Seminar on Microstructures
Essen, January, Lecture, Poster

10th German Probability and Statistics Days
Mainz, March, Lecture

Hannover-Messe
Hannover, April, Exhibitor

Hofer Vliesstofftage
Hof, November, Exhibitor, Lecture

HPCS 2012
Madrid (E), July, Lecture

IAA Nutzfahrzeuge
Hannover, September, Exhibitor

12th IAEE European Energy Conference
Venedig (I), September Lecture

IAM-Conference
Ankara (TR), October, Lecture

IASS International Workshop "Renewable Energy Perspectives in Latin America in the international context"
Potsdam, October, Lecture

IdeenPark 2012
Essen, August, Exhibitor

Industriearbeitskreis Ressourceneffizienz in der NFZ-Branche
Kaiserslautern, September

Informatikertag der Hochschule Mittweida
Mittweida, October, Lecture

Infotag: EU-Förderungen für Forschung und Innovation
Kaiserslautern, October

InnoMateria
Köln, May, Exhibitor

Innovation 2012
München, October, Exhibitor

International Annual Conference of the German OR Society 2012
Hannover, September, Lecture

3rd International Conference of Engineering Optimization EngOpt 2012
Rio de Janeiro (BR), July, Lecture

International Conference on 3D Materials Science 2012
Seven Spring (USA), July, Lecture

International Conference on Acoustics, Speech, and Signal Processing
Kyoto (J), March, Poster

21st International Conference on Pattern Recognition 2012 (ICPR)
Tsukuba (J), November, Lecture

PRICES AND AWARDS

13th International Conference on Project Management and Scheduling
Leuven (B), April

International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design (SMACD)
Sevilla (E), September, Lecture

7th International Conference: Stereology, Spatial Statistics and Stochastic Geometry
Prag (CZ), June, Lecture

International Ruhr Energy Conference 2012
Essen, March, Lecture

International Supercomputing Conference
Hamburg, June, Exhibitor, Lecture

3rd International Symposium on Focused Ultrasound MRgFUS 2012
Washington (USA), October, Poster

21st International Symposium On Mathematical Programming
Berlin, August, Lecture

4th International Symposium on NDT in Aerospace
Augsburg, November, Lecture

International Workshop on Evolution problems in damage, plasticity and fracture: mathematical models and numerical analysis
Udine (I), September, Lecture, Poster

38th International Workshop on Graph Theoretic Concepts in Computer Science
Ramat Rachel (IL), June, Lecture

2nd International Workshop on Multiscale Modelling and Methods
St. Etienne (F), October, Lecture

Intersolar
München, June, Exhibitor

Kraftwerk Batterie
Münster, March

MathFinance Conference 2012
Frankfurt, March

mtex – Internationale Fachmesse
Chemnitz, May, Exhibitor

Multikonferenz Wirtschaftsinformatik
Braunschweig, February, Lecture

Nacht, die Wissen schafft
Kaiserslautern, November, Exhibitor

NAFEMS European Conference "Multiphysics Simulation"
Frankfurt, October, Lecture

Offener Campus der Fachhochschule Kaiserslautern
Kaiserslautern, May, Exhibitor

PDESoft
Münster, October, Lecture

PGAS 2012
San Antonio (USA), October, Lecture, Poster

ProcessNet Jahrestagung
Karlsruhe, September

PV Power Plants Conference, Solarpraxis
Wien (A), March

6th R/Rmetrics Meielisalp Workshop & Summer School 2012 on Computational Finance and Financial Engineering
Meielisalp (CH), June, Lecture

SEG 2012
Las Vegas (USA), November, Exhibitor

Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung«
Karlsruhe, November, Exhibitor, Lecture

SIAM Conference on Imaging Science (IS12)
Philadelphia (USA), May, Lecture

SIMVEC 2012
Baden-Baden, November, Exhibitor, Lecture

Spring school on mathematics of multiscale problems
Kaiserslautern, April, Lecture, Poster

Statistische Woche
Wien (A), September, Lecture

Supercomputing'12
Salt Lake City (USA), November, Exhibitor, Lecture

Symposium »Textile Filter«
Chemnitz, March, Exhibitor

Ter@Tec
Palaiseau (F), June, Exhibitor

Textil Innovativ: Automobil – Sport – Mode
Fürth, February, Exhibitor, Lecture

Tire Technology Expo 2012
Köln, February

VDI Wissensforum: 70. Internationale Tagung LAND.TECHNIK 2012
Karlsruhe, November, Exhibitor, Lecture

Vision 2012
Stuttgart, November, Exhibitor

Workshop Robust Methods for Dependent Data
Witten, February, Lecture, Poster

6th World Bachelier Society Congress 2012
Sydney (AUS), June, Lecture

4th World conference on 3D fabrics and their applications
Aachen, September, Lecture, Poster

18th World Conference on NDT
Durban (ZA), April, Lecture

World Filtration Congress 11
Graz (A), April, Exhibitor, Lecture

19th World Hydrogen Energy Conference
Toronto (CDN), June, Lecture

Dobrovolskij, Dascha
DGZfP-Studentenpreis
Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V., Berlin
March

Horbenko, Nataliya; Ruckdeschel, Peter; Bae, Taehan
Paper of the Year
Operational Risk and Regulation (Innovation Award 2012)
March

Nickel, Stefan
Top Cited Article 2007 – 2011
Elsevier, European Journal of Operational Research

Nickel, Stefan
EURO Award 2012
EURO The Association of European Operational Research Societies
July

Wagner, Andreas
Best Paper Award
Energy Finance Conference 2012
October

OWN EVENTS

2nd Commercial Vehicle Technology Symposium
Kaiserslautern, March

Opening ceremony of the extension building of Fraunhofer ITWM
Kaiserslautern, August

Fraunhofer-Innovationscluster »Digitale Nutzfahrzeugtechnologie – Fahrzeug-Umwelt-Mensch«: Workshops: »Statistik und Nutzungsvielfalt« und »Simulation / Virtuelle Produktentwicklung«
Kaiserslautern, October

GeoDict Training Workshop
KAUST SRI Center on Numerical Porous Media, Jeddah (KSA), October

GeoDict User Meeting
Kaiserslautern, October

Joint Workshop: Centre de morphologie mathématique CMM – ITWM (Deutsch-Französische Hochschule DFH)
Kaiserslautern, October

Mathematics of Multiscale Problems
Kaiserslautern, April

Modellierung, Simulation und Optimierung in der Verfahrenstechnik
Annweiler, June

Nacht, die Wissen schaft
Kaiserslautern, November

OptiRisk Workshop: Application of Hidden Markov Models and Filters to Financial Time Series Data
London (UK), April

OptiRisk Workshop: Monte Carlo Methods in Finance: Basic Methods and Recent Advances
London (UK), May

Seminar: Lastdaten – Analyse, Bemessung und Simulation
Kaiserslautern, June

Seminar: Statistische Methoden in der Betriebsfestigkeit
Kaiserslautern, May

Summer tour of RHEINPFALZ
Kaiserslautern, August

Summer School des Felix-Klein-Zentrums für Mathematik
Kaiserslautern, September

Verbundseminar 2012: Produktion von Filamenten und Vliesstoffen – ProFil
Johns Manville, Bobingen, May

Verbundtreffen: Stochastische Produktionsprozesse zur Herstellung von Filamenten und Vliesstoffen - ProFil
Kaiserslautern, October

Lecture series "The broader view"
Kaiserslautern, 9 Lectures

Vortragsreihe des Arbeitskreises »Bildanalyse und Mustererkennung Kaiserslautern« (BAMEK)
Kaiserslautern, 4 Lectures

Workshop: Application of Hidden Markov Models
Birkbeck/London, April (in Kooperation mit OptiRisk)

Workshop: Basis-Spreads and OIS-Discouinting
Kaiserslautern, September

Workshop: Batteriesimulation
Kaiserslautern, April

Workshop: Cambridge-Kaiserslautern Finance Alliance
Kaiserslautern, March

Workshop: Computational Fluid dynamics and scientific computing
Lahore University of Management Sciences (LUMS), Lahore (PK), December

Workshop: Das Hestonmodell – Theorie und praktische Implementation
Kaiserslautern, February

Workshop: Extremwertstatistik und operationelle Risiken
Kaiserslautern, May

Workshop: Finanzmathematik und R
Kaiserslautern, September

Workshop: Konzeptentwicklung Scheduling Framework
Annweiler, February

Workshop: Kredit Rating
Kaiserslautern, September

Workshop: Mehrfaktorzinsmodelle und ihre Implementation
Kaiserslautern, November

Workshop: Modeling and simulation of industrial processes in porous media
KAUST SRI Center on Numerical Porous Media; Jeddah (KSA), June

Workshop: Moderne Monte-Carlo Methoden mit Anwendungen in der Finanz- und Versicherungsindustrie
Kaiserslautern, June

Workshop: Multilevel Monte-Carlo Methoden und Simulation
Kaiserslautern, June

Workshop: Short-Rate-Zinsmodelle und ihre praktische Anwendung
Kaiserslautern, November

GUESTS

Abreu, Domingo Hernandez (Universidad de La Laguna, Santa Cruz de Tenerife (E))
Numerik stochastischer partieller Differentialgleichungen
July

Arnold, Martin (Martin-Luther-Universität Halle-Wittenberg)
Numerik für Mehrkörpersysteme
Februar

Bechet, Fabien (Universität Valenciennes (F))
Formgebung von Glas
September

Betsch, Peter (Universität Siegen)
Modellierung von Reifen mit geometrisch exakten Schalenmodellen
June

Biere, Armin (Johannes-Kepler-Universität, Linz (A))
SAT-based Model-Checking
March

Busch, Michael (Finanzagentur Frankfurt)
Schuldenmanagement für die Bundesrepublik Deutschland – Die Aufgaben eines quantitativen Risikocontrollers
Dezember

Christensen, Sören (Universität Kiel)
Optimal stopping of strong Markov processes
Februar

Dreyer, Wolfgang (Weierstrass-Institut, Berlin)
Thermodynamische Modellierung und Analyse von Phasenübergängen
Februar

Eisenträger, Almut (University of Oxford, London (UK))
Mehr-Flüssigkeits-poroelastisches Modell der Gehirn-Rückenmarks-Flüssigkeit während eines Infusionstests
October

Gerdts, Matthias (Universität der Bundeswehr, München)
Echtzeitreifen für SNiMoRed
April

Godsill, Simon
(Cambridge University (UK))
Computational Models for Continuous-Time non-Gaussian Time Series
March

Juhre, Daniel (DIK Hannover)
Nichtlinear viskoelastische Modellierung und Simulation von Elastomer-Werkstoffen
Januar

Kestel, Sevtap (METU Ankara (TR))
On longevity and the Turkish Pension System
November

Kohl, Matthias
(Hochschule Furtwangen)
R-Pakete zu Robuster Statistik
July

Kroflic, Ales
(University of Ljubljana (SLO))
Nichtlineare Strukturmechanik mit Cosserat-Balkenmodellen
November

Lacoursière, Claude
(Umea University (S))
Non-smooth multi-domain simulation
August

Lerch, Sebastian
(Universität Heidelberg)
Verification of probabilistic forecasts for rare and extreme events
July

Maas, Ramona (Friedrich-Alexander-Universität, Technische Fakultät, Erlangen-Nürnberg)
Muskelmodelle in biomechanischen MKS-Modellen
August

Michel, Volker (Universität Siegen)
Regularisierung tomographischer inverser Probleme in der Geophysik und der medizinischen Bildgebung mit Techniken der Konstruktiven Approximation
Januar

Müller, Gernot (TU München)
Are jumps in price and volatility correlated?
June

Niedziela, Maciej
(University Zielona Gora (PL))
Viscoelastic Materials
September

Oesting, Marco
(Universität Mannheim)
Conditional Modelling of Spatial Extremes
July

Panasenko, Grigory (Jean-Monet-Unversität, St. Etienne (F))
Homogenization and shape optimization in thin periodic structures
April

Rentrop, Peter (TU München, M2-Zentrum Mathematik)
Wiener Calculus for Differential Equations with Uncertainties
July

Rogers, Chris
(University of Cambridge (UK))
Least Action Filtering
March

Scheuerer, Michael
(Universität Heidelberg)
Making and Evaluating Point Forecasts
July

Schlather, Martin
(Universität Mannheim)
Maxima of Gaussian Random Fields
July

Struckmeier, Jens
(Universität Hamburg)
Asymptotische Methoden der Angewandten Mathematik
September

Wardetzky, Max
(Universität Göttingen)
Diskrete nichtlineare Schalenmodelle
August

Zupan, Eva; Zupan, Dejan
(University of Ljubljana (SLO))
Nichtlineare Strukturmechanik mit Cosserat-Balkenmodellen
July

Andrä, Heiko
- Journal Of Computational Physics JCOMP (Reviewer)
- Structural and Multidisciplinary Optimization SMO (Reviewer)
- Latvian Science Council (Reviewer)

Didas, Stephan
- Image Processing On-Line (Editor)
- Journal of Mathematical Imaging and Vision (Reviewer)
- Pattern Recognition (Reviewer)
- IEEE Transactions on Image Processing (Reviewer)
- International Journal of Imaging (Reviewer)
- International Journal of Imaging Systems and Technology (Reviewer)

Horbenko, Nataliya
- Journal of Operational Risk (Reviewer)
- Methods of Information in Medicine (Reviewer)
- Conference on Operational Risk Measurement and Management (Scientific committee)

Iliev, Oleg
- International Society for Porous Media (President)
- Mathematical Modelling and Analysis (Editor)
- SIAM Multiscale (Reviewer)
- Transport in Porous Media (Reviewer)
- J. Comp and Appl. Math (Reviewer)
- Chemical Eng. Journal (Reviewer)
- Computational Geoscience (Reviewer)

Korn, Ralf
- Deutsche Gesellschaft für Versicherungs- und Finanzmathematik (Vice Chairman)
- Scientific advisory board of DISC (University of Kaiserslautern)
- European Actuarial Journal (Editor)
- Mathematical Finance (Associate Editor)
- Mathematical Methods of Operations Research (Associate Editor)
- Imperial College Press/World Scientific: "Quantitative Finance Series" (Editor)
- Springer Briefs in Mathematical Finance (Editor)
- Scandinavian Statistical Journal (Associate Editor)
- Reviewer for DFG, AQAS, Studienstiftung des Deutschen Volkes, Humboldt-Stiftung

Küfer, Karl-Heinz
- Computers & Operations Research (Reviewer)
- Medical Physics (Reviewer)
- Physics in Medicine and Biology (Reviewer)
- European Journal of Operations Research (Reviewer)

Kuhnert, Jörg
- Scientific Committee, ESI Group, Paris (F) (Member)

Maasland, Mark
- Fraunhofer Vision Alliance (Member)

Neunzert, Helmut
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Vice Chairman of Advisory Board)

- International Committee for Applied Mathematics in the European Mathematical Society (Member)
- Technology ambassador of town and county Kaiserslautern
- ECMI-Series "Mathematics in Industry" (Editor)

Ostermann, Isabel
- International Journal on Geomathematics (Reviewer)
- Numerical Functional Analysis and Optimization (Reviewer)

Pfreundt, Franz-Josef
- Unconventional High Performance Computing (UCHPC'12) (Member Program Committee)
- ISC'12 Steering Committee (Member)
- ISC Cloud'12 Panel (Member)

Prätzel-Wolters, Dieter
- Forschungszentrum »Center of Mathematical and Computational Modeling (CM)²« der Technischen Universität Kaiserslautern (Member)
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Board member)
- GAMM-Fachausschuss »Dynamik und Regelungstheorie« (Member)
- Graduiertenkolleg »Mathematik und Praxis« der Technischen Universität Kaiserslautern (Member)
- Presidential council and senate of Fraunhofer-Gesellschaft (Member)
- Rheinland-pfälzischer Landesforschungsschwerpunkt »Mathematik und Praxis« (Member)
- Stiftungsrat »Fraunhofer-Zukunftsstiftung« (Member)
- Wissenschaftlich-Technischer Rat und Hauptkommission der Fraunhofer-Gesellschaft (Chairman)
- Felix-Klein-Zentrum für Mathematik (Vice Chairman)
- BMBF Strategiekommittee für mathematische Modellierung, Simulation und Optimierung (KoMSO) (Member)

Rieder, Hans
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, personal Member)
- DGZfP Fachausschuss »Ultraschallprüfung« (Member)
- DGZfP Unterausschuss »Phased Array« im Fachausschuss Ultraschallprüfung (Chairman)
- VDE/VDI-Fachausschuss »Nichtlineare Systeme« (Member)

Rösch, Ronald
- Image Processing On-Line (Editor)
- Fraunhofer Vision Alliance (Koordinationsrat)
- Fraunhofer Lightweight Structures Alliance (Member)
- Heidelberger Bildverarbeitungsforum (Beirat)
- IOP electronic Journals (Reviewer)
- GACR (Reviewer)
- Fraunhofer-Arbeitskreis Computertomographie (Member)
- Deutsche Gesellschaft für Materialkunde e. V. (DGM, Member)
- DGM-Arbeitskreis »Tomographie« (Member)
- DGM-Fachausschuss »Strahllinien« (Member)
- DGM-Arbeitskreis »Quantitative 3D-Mikroskopie von Oberflächen« (Member)
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, Member)

Ruckdeschel, Peter
- Computational Statistics and Data Analysis (Reviewer)
- Communications in Statistics – Theory and Methods (Reviewer)
- Journal for mathematical modelling and analysis (Reviewer)
- Statistical Papers (Reviewer)
- Journal of multivariate analysis (Reviewer)
- Technometrics (Reviewer)

Scherrer, Alexander
- Physics in Medicine and Biology (Reviewer)

Schladitz, Katja
- Fraunhofer-Allianz Leichtbau (Member)
- International Society for Stereology (Vice-President for Europe)
- Metals (Reviewer)
- Journal of Microscopy (Reviewer)
- Image Analysis & Stereology (Editorial Board)

Schröder, Michael
- Computers & Operations Research (Reviewer)

Spies, Martin
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, personal Member, deputy Chairman)
- DGZfP Fachausschuss »Ultraschallprüfung« (Member)
- DGZfP Fachausschuss »Hochschullehrer« (Member)
- DGZfP Unterausschuss »Modellierung und Bildgebung« im Fachausschuss »Ultraschallprüfung« (Chairman)
- DGZfP Unterausschuss »Ausbildung« im Fachausschuss »Ultraschallprüfung« (Member)
- DGZfP Unterausschuss »Phased Array« im Fachausschuss »Ultraschallprüfung« (Member)
- IEEE Transactions on Ultrasonics, Ferroelectrics & Frequency Control (Reviewer)
- Journal of the Acoustical Society of America (Reviewer)
- Journal of Computational Acoustics (Reviewer)
- Materials Evaluation (Reviewer)
- NDT&E International (Reviewer)
- Wave Motion (Reviewer)
- Ultrasonics (Reviewer)
- Acustica (Reviewer)

Stephani, Henrike
- International Conference on Pattern Recognition (ICPR, Reviewer)

Vecchio, Irene
- Bernoulli Society (Member)
- Deutsche Gesellschaft für Materialkunde e. V. (DGM, Member)

Velten, Sebastian
- Computers & Operations Research (Reviewer)
- TOP (Reviewer)

Wagner, Andreas
- IEEE Transactions on Power Systems (Reviewer)

Wenzel, Jörg
- Mathematical Reviews (Reviewer)
- Zentralblatt der Mathematik (Reviewer)

Wirsen, Andreas
- Fraunhofer Adaptronics Alliance (Member)

Zemitis, Aivars
- Mathmatical Modelling and Analysis (Editor)

PATENTS

Mammitzsch, Lars; Petasch, Uwe; Adler, Jörg; Wiegmann, Andreas; Cheng, Liping
Partikelfilter
Patent application 2012 together with Fraunhofer IKTS

Shalf, John; Donofrio, David; Oliker, Leonid; Krüger, Jens; Williams, Samuel
Multiple-core computer processor for reverse time migration
International patent
WO002013063486A1

Contact
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