ANNUAL REPORT

2010/11

CONTENT

Any expectations of increasing industrial revenues or of budget or staff growth at ITWM were very subdued at the start of 2010. The first quarter was characterized by a difficult situation for industry projects which if extrapolated throughout the full year, would have clearly indicated a further collapse in the economy in the area of contract research. This perspective is what lead all departments to undertake comprehensive initiatives in the area of industrial project acquisition. In the end, these initiatives proved to be very effective and, together with the onset of the economic recovery later in the year, resulted in significantly higher industrial revenues compared to the crisis year 2009. And, we also closed out the year 2010 with budget and staff growth.

The public sector revenues also continued to grow in 2010. ITWM particularly welcomed the substantial support granted for the first time by the Federal Ministry of Education and Research (BMBF) under the development program "Mathematics for Innovation in Industry and Services." A series of joint ventures with the participation of commercial partners like Adam Opel GmbH, Infineon, John Deere, and Wyatt Technology are addressing leading edge research topics in applied mathematics such as multi-disciplinary simulation, non-linear model reduction, geometric structural mechanics, stochastic models for production processes or micro and nano structures, and multi-criteria optimization.

Another building block which helps secure public sector revenues beyond the year 2010 is the participation of ITWM in the federal government's cluster of excellence initiative "Innovative Software for the Digital Enterprise," which provides funding of 80 million euros over the next five years. The sites included in this top cluster include the cities of Darmstadt, Karlsruhe, Kaiserslautern, Saarbrücken, and Walldorf. The focus of work in Kaiserslautern is the business process optimization research being performed at ITWM, IESE, DFKI, and the technical university. ITWM contributes support in the planning of intelligent, adaptive production processes with data-based methods.

A highlight of 2010 was the establishment of new Fraunhofer Innovation Cluster ("Vehicle – Environment – Human Interaction") at the Kaiserslautern location. This new cluster consolidates recently conducted research that focused on "digital commercial vehicle technologies" with new topics and initiatives and expanded membership in the industrial consortium. In addition to ITWM, other participants include the Fraunhofer Institute for Experimental Software Engineering and the Kaiserslautern Terahertz project group of the Fraunhofer Institute for Physical Measurement Techniques (IPM) in Freiburg. The state of Rhineland Palatinate, the Fraunhofer-Gesellschaft, and an industry consortium are providing project funding of 10 million euros to the cluster for the period 2010-2013.

Renewable energy, a topic of growing interest since the recent events in Japan, has become a major topic for the future of Germany's energy supply and a subject of intense research at ITWM with a mathematics perspective. The state is supporting its recently established focus on "mathematics as an innovation driver" by funding two impulse projects for renewable energies. The "mySmartGrid"project, with financing from the second economic stimulus package, is developing an open alternative to current smart grid solutions and bringing it to selected consumers according to the fluctuating availability of various energies. The "myPowerGrid" project is funded by the European Regional Development Fund (EFRE) and the Ministry of the Environment of Rhineland-Palatinate. The project examines the construction of a distributed energy storage system for the future and its integration with a regenerative combined power plant. Both projects are developing new techniques for planning and implementing an efficient system for using fluctuating energy sources in terms of consumption, storage, and distribution based on mathematical modeling, simulation, and optimization.

We note with pride how the "Fraunhofer-Chalmers Center for Industrial Mathematics," jointly established with Chalmers Technical University in 2001 continues to grow. The Center exceeded the goals set in its business plan, with the number of staff growing faster than planned and a dynamic expansion of its scientific competencies. Our entry into the Swedish market got off to a good start with ITWM participating is a series of industrial projects. In view of these positive developments, the Executive Board of Fraunhofer-Gesellschaft has acted to stabilize the engagement of the Gesellschaft in the form of project grants until the year 2015.

The construction of the ITWM building expansion began at the end of November and has a target completion date at the end of the first quarter 2012. Additional office space is planned as well as two new labs equipped with the latest technology standards to serve as an interface between mathematical innovation and industrial applications. I also express once again my appreciation to the Fraunhofer-Gesellschaft and the government of Rhineland-Palatinate for taking notice of our extraordinary development and for providing the financial means necessary for our expansion.

ITWM is slowly coming of age – five years as a government research institute and ten years as a member of the Fraunhofer-Gesellschaft – and looking back in review on a success story for the mathematics disciplines as well. Mathematics as a key technology for economic and social innovation – what was still just a vision fifteen years ago– has become an accepted fact. ITWM has played its part – steady growth with high earnings, a budget that has almost doubled in the last five years, and many innovative projects with numerous national and international partners are the indicators of our success. However, the network of Fraunhofer Institutes also contributed greatly to this success. ITWM is very well connected in the Fraunhofer-Gesellschaft through a number of joint research ventures with other institutes, especially under the framework of internal programs. The synergy among the Fraunhofer Institutes regarding specific mathematical modeling and numerical simulation competencies form the basis of a network, which has grown over the years and functions extremely well with complementary competencies combined in joint projects and, as a rule, encounters little competition in the marketplace.

In closing, I want to recognize our employees and express my appreciation for their performance and achievements. ITWM is a mathematics institute and with relatively few lab facilities, depends in a very unique way on its "human capital" for the exciting area between research and technology transfer. The untiring effort by the staff, their competencies, and their commitment to our vision and goals are the decisive factors that determine the long term success of the institute.

In choosing the illustrations, we focused on the theme of the Year of Science 2011: "Research for Our Health." The themes of medicine and health are being addressed at ITWM in several projects and mathematics as an innovation driver for customized medicine is one of the institute's "new futures." We are also participating in Science Summer 2011 in Mainz, where we will present our work on model and simulation-aided therapy planning, hospital logistics, optimization of prosthetic knees, and the delivery of medication to the inner ear.

We appreciate the continued support and the very successful and productive cooperation with our partners and friends. We look forward to a confident future in which we earn the trust placed in us and continue to perform to the standards and goals of the Fraunhofer-Gesellschaft.

Prof. Dr. Dieter Prätzel-Wolters
Director of ITWM

1 © Volvo


2

INNOVATION CENTER FOR APPLIED SYSTEM MODELING FOUNDED

1 *High-tech for tractors and trucks was the theme at 1st Commercial Vehicle Technology Symposium*

2 *Interview with a young visitor on Science Evening*

The new Kaiserslautern Innovation Center has been meeting under the motto "Science meets engineering" since January 2010. To strengthen existing cooperation, the center brings Fraunhofer ITWM and IESE and the departments of Information Systems and Mathematics at TU Kaiserslautern even closer together. Current plans have the Innovation Center running for eight years; the first four are already funded with a total of 12.8 million euros. The government of Rhineland-Palatinate granted 6.4 million euros with the Kaiserslautern Fraunhofer Institute and the Fraunhofer-Gesellschaft together contributing equity capital of the same magnitude. Joint research ventures and contract research projects are expected to raise an additional three million euros in the initial phase. The "Innovation Center for Applied System Modeling," promotes joint strategies and projects with the aim of creating new fields of business in innovative areas of applied mathematics and information systems.

1ST COMMERCIAL VEHICLE TECHNOLOGY SYMPOSIUM

ITWM was one of the sponsors of the 1st Commercial Vehicle Technology Symposium, which took place in March at TU Kaiserslautern. In keeping with the motto "Science meets engineering," more than 250 commercial vehicle experts came together under the sponsorship of the Office of the Minister President. The conference was opened by Science Minister, Doris Ahnen. The latest technologies were presented and discussed in more than 50 lectures in the areas of design, production, calculation, electrical, electronic, and software systems in the commercial vehicle branch. The conference is planned as a bi-annual event to provide national and international experts from the research and industrial communities to meet and exchange information and experience in the areas of trucks, buses and agricultural and construction machinery.

SCIENCE EVENING

Science you can listen to, join-in, and touch was the focus of the first Science Evening in Kaiserslautern where venues at two universities (TU and FH) and research institutes demonstrated what it is that they do: Surface inspection, freeform lenses, digital vehicle technology, and optimal gemstone polishing are just some of the topics presented at ITWM. A presentation highlighted the tightly linked network with the regional economy. The local Kaiserslautern band "Cameleon" performed in the foyer and the evening's finale was the well-attended reading by Rainer Furch and Madeleine Giese on the subject Mathematics in Literature: "What the numbers tell you."

BESSEL-PRIZE WINNER AT ITWM

Yalchin Efendiev, Professor for Mathematics at Texas A&M University and Director of the Institute for Scientific Computation there, has been a visiting scholar at ITWM several times before, but the reason this time was special: Efendiev was awarded the Bessel-Prize. The prize includes a grant of 45,000 euros donated jointly by Humboldt Foundation and Fraunhofer-Gesellschaft, which allows the distinguished winners to work on a research project of their own choosing in cooperation with colleagues at one of the sixty Fraunhofer Institutes. Prof. Yalchin Efendiev has chosen to direct his efforts this time in Kaiserslautern mainly to the advanced development of his efficient numerical process for multi-scale simulations and transfer to the multi-scale design problems of filters and insulating materials currently being examined by ITWM.

3 *Corner stone ceremony for ITWM expansion*

4 *Topping-out ceremony at Felix Klein Center for Mathematics on the TU campus*

TOPPING-OUT CEREMONY AT FELIX KLEIN CENTER

Fraunhofer ITWM and the mathematics department have a long tradition of close cooperation in research, practical application, and education. The Felix Klein Center, initially conceived to present a consistent identity, was established as an institutional link to strengthen the study of mathematics in Kaiserslautern and it now has an even stronger foundation: The topping out ceremony for the new building of the Felix Klein Center on the campus of the university was celebrated at the end of October. Five math professors and their research groups will begin to occupy rooms in the new three story annex to this international meeting place during mid-year 2011. These additional research groups will contribute greatly to the close interchange of ideas between the applied research conducted by the ITWM departments and the theoretical work of parallel groups at the Faculty of Mathematics.

GROUND BREAKING CEREMONY FOR ITWM EXPANSION

The construction of the ITWM building expansion began at the end of November and the construction schedule call for the rooms to be ready for occupation by the researchers by mid-2012. Over the course of the past few years, ITWM has continued to grow to the point that the Fraunhofer Center, the complex it occupied in January 2006, no longer offers sufficient space. The annex represents the architectural boundary to the city and will be two stories taller than the current building. More than just an office building – according to plans, the building will house two state of the art labs with the latest technological standards and serve as the interface between mathematical innovation and industrial application.

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2 © planungsgruppeDREI

FELIX KLEIN CENTER FOR MATHEMATICS

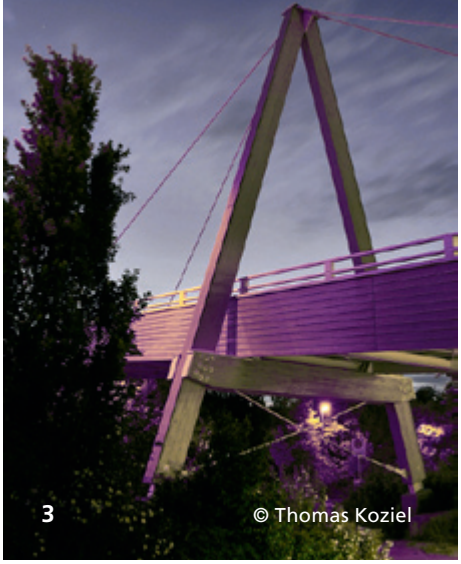
FELIX KLEIN
ZENTRUM FÜR
MATHEMATIK

First, an explanation of the name: "Felix Klein (1849-1925) is one of the most fascinating mathematicians of the time around the turn of the last century and the impact of his work is still felt to this day. Besides his outstanding mathematical skills, Klein possessed amazing pedagogic and organizational talents and it is this rare combination that assured him great influence in the development and shaping of modern mathematics. He was the uncontested leader of the mathematic world for many years. In addition to his pedagogic and organizational contributions, Klein is well known for his contributions to geometry and group theory as well as his studies of the elliptic modular functions and rotating bodies (Kreisel theory). The cities where he worked include Göttingen, Erlangen, Munich, and Leipzig, and lecture trips to the USA were even part of his tireless mathematical activities." - Renate Tobies, Felix Klein, Teubner 1981.

No, Felix Klein was never in Kaiserslautern, but his ideas still serve as an example today. They are central concepts that mathematicians in Kaiserslautern today still want to see continued even beyond 2010. The mathematicians of Kaiserslautern: those in the department of Mathematics at TU Kaiserslautern that always achieve the highest rankings in the university ratings – and those mathematicians of Fraunhofer ITWM. They are not only neighbors, but together they form a symbiosis. Many TU mathematicians consult with ITWM scientists and ensure the next generation of Fraunhofer researchers, for example, by serving as advisors to doctoral candidates. ITWM mathematicians lecture at the TU and third party scholarship funding for Master and PhD scholars flows into the TU. In brief, cooperative research and cooperative organization results in cooperative education – just the way Felix Klein would have wanted it.

However, as the two facilities are organizationally separate entities, it is helpful when they can get together under a common umbrella. This umbrella is a registered non-profit association for the promotion of mathematics: the Felix Klein Center. This umbrella does not only facilitate getting together, the scientists also work together, especially in attracting the next generation of scientists. To do this – just as Felix Klein has done before – it is essential to begin at a very early stage, in the high schools. "In accord with the accepted level of scientific knowledge, he wanted to lift the instruction to a higher theoretical level. At the same time, he also spoke consistently of a second requirement - to achieve a clear, application oriented, practical design of the instruction without injuring the systematic of the curriculum" (Tobies, p. 75). The aim of the Felix Klein Center is to realize these two ambitions through various different measures.

Mathematical modeling is one of the core competences of ITWM. It should also be taught at schools and universities – according to many others in addition to the mathematicians at the



Felix Klein Center. Unfortunately, this is seldom the case and the reason why the Felix Klein Center organizes two or three "Modeling weeks" per year for top high school students. The week-long program is conducted at neutral location e.g., at a youth hostel, and involves several groups of approximately five students and two teachers that work together to solve practical problems. Furthermore, there are up to eight Felix Klein scholarships granted each year to deserving high school graduates all across Germany to help convince them to pursue the study of mathematics (in Kaiserslautern); The scholarships consist not only of a tidy sum of money each month, but also assign a mentor from ITWM, who introduces the young mathematicians to the professional world of mathematical research. They attend lectures and meet well-known guests at the institute.

Every year, ITWM organizes a summer school in which the Felix Klein Scholarship holders are introduced to advanced mathematical subjects that are outside the basic course but have a practical orientation, e.g., inverse problems, multi-scale signal analysis, interactive solutions to equations, etc. We are continuing the ideas of Felix Klein, taking instruction to a higher theoretical plane with a practical, application-oriented design.

Felix Klein was also interested in the history of science: his lectures about "The development of mathematics in the 19th century," from 1926, make for exciting reading even today. The Felix-Klein Center has also invited the New York historian Myles W. Jackson to ITWM in the three summer months of 2011 to continue his studies related to the work at Fraunhofer and in the process, expose the Felix-Klein Scholarship holders to the historical perspective, which is something Felix Klein would have surely approved. ITWM also funds the Felix Klein Prize for the "European Mathematical Society" every four years. The prize is awarded for excellence in the field of "Industrial Mathematics" and includes 5000 euros in prize money.

Felix Klein was 19 years old when he earned his PhD in Bonn. On the fiftieth anniversary of his doctoral degree in 1918, many mathematicians organized a conference and wrote a letter addressed to "to his most honorable councilor." The letter states: "In you we see more than the pioneering research scientist, who developed new paths for our discipline. At the same time, we admire you as a tireless friend and helper, who always gave generously from the richness of his ideas, in both written and spoken words, to like-minded practitioners. We also admire in you the brilliant teacher who understood how to gain a large number of students for our science and who listen in wonder to the stimulating magic of your lectures." Today, we still feel a bit of this magic in Kaiserslautern.

1 *Felix Christian Klein (1849 – 1925)*

2 *New building for Felix Klein Center on the campus of TU Kaiserslautern*

3 *Foot bridge from the "Science mile" to TU Kaiserslautern*

4 *Modeling Week for area high school students*

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 guest 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: Adaptronics, Energy, Simulation, Water Systems, Traffic and Transportation, Vision (image processing), Cloud Computing, and Automobile Production.

Martin Braun, Tino Labudda, Dr. Elmar Gerwalin, Martin Vogt, Prof. Dr. Helmut Neunzert, Brigitte Williard, Prof. Dr. Dieter Prätzel-Wolters, Michaela Grimberg-Mang, Anja Nitschky, Manuela Hoffmann, Katharina Parusel, Klaus Linck, Michael Mannweiler
Christian Peter, Dieter Eubell, Gabi Gramsch, Mirko Spell, Dr. Marion Schulz-Reese, Markus Pfeffer, Sylvia Gerwalin, Ilka Blauth, Gesa Ermel, Steffen Grützner

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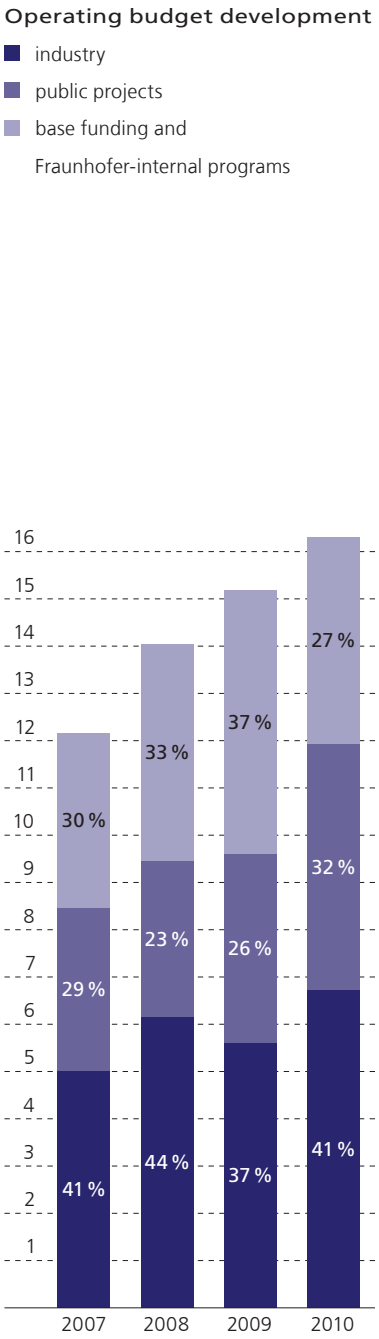
BUDGET

Operating budget development in million €



In April, experts still thought that the international economic and financial crisis would cause industrial revenues for ITWM to continue to drop in 2010. There was nothing at that time to indicate that the year 2010 would actually become one of ITWM's most successful years. The order book was down compared to the same period one year earlier. However, this was compensated in part by a continued increase in revenue from the public sector, to the point that financing for the institute for 2010 was already secure at a very early date. ITWM also profited immensely from the business recovery in the German and European economies – especially in the areas of automotive and mechanical engineering – in the second half of the fiscal year 2010, and even the most optimistic expectations were exceeded in almost all business segments. Industrial revenues actually increased compared to the previous year by almost 20 percent, so that at the year-end close for 2010, ITWM reported a share of industrial revenues of 41.2 percent. This result would not have been possible without the strong engagement of all employees, especially those in order acquisition. It is noteworthy that in 2010 for the first time, more than half of the industrial revenues originated from small and middle size enterprises. A large share of the business earnings, namely more than 36 percent, came from international business orders. Almost the same amount, namely 32 percent, came from local and regional businesses. Overall, ITWM was able to rely on its "regular customers" as well as being pleasantly surprised by a large number of contracts awarded by new customers. Compared to the previous year, the operating budget saw a relatively conservative increase of 5 percent, which to some extent is related to the somewhat hesitant hiring policy in the first half of the year. The public sector contracts accounted for an additional 36 percent and also, the revenue from internal programs could be retained at a high level. The outlook for 2011 regarding industrial orders and public grants is very positive and ITWM is taking a very optimistic view of the future. This surely means

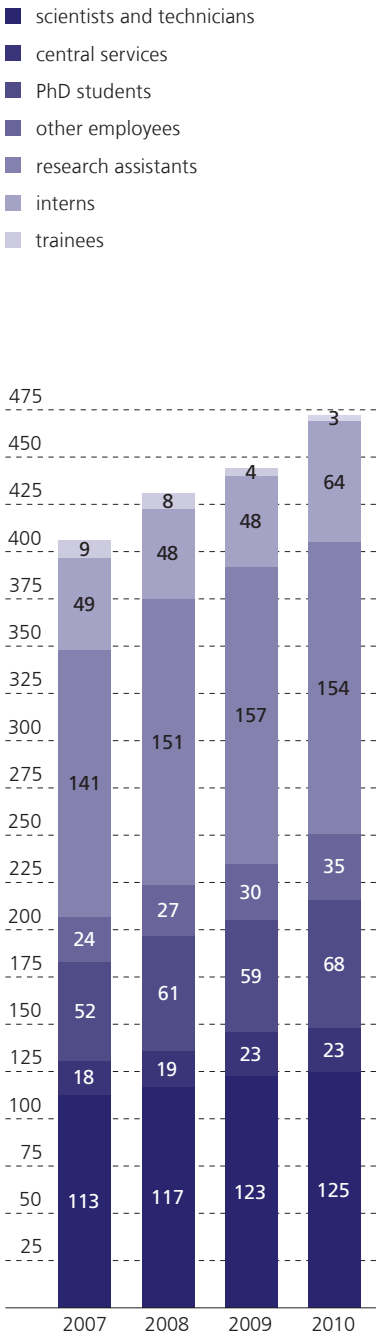
further, not insignificant, increases in the number of employees in 2011, which considering the already crowded offices at the institute and the fact that the new construction will not be ready to occupy until 2012, means that temporary leasing of external office space will be required.

Budget development*	2007	2008	2009	2010
Operating budget	12163	14035	15170	16315
Investments	1720	383	894	550
Total	**13883**	**14418**	**16064**	**16865**

*thousand €

PERSONNEL DEVELOPMENT

In the light of the slow growth in new orders during the first half of 2010, the hiring of new staff did not begin until the second half. Somewhat balancing the 14 new hires were 11 departures, so hardly any growth was reported by the HR department. All the more gratifying was the fact that of the 14 new hires, a total of 9 scientists were recruited from our own ranks of young talented researchers. This is an indication of the outstanding program to promote junior staff at ITWM. The large number of PhD candidates – 68 in 2010 – assures not only excellence in research, but also provides ITWM access to highly educated scientists in these times of a growing shortage in the availability of qualified staff. The 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 very productive. The aim of ITWM and the TU, under the umbrella of the Felix Klein Center, is to attract more students to the study of MINT subjects by organizing more joint activities at the secondary education level. Consequently, more joint activities are being planned for the "Fraunhofer-Talents!" program, a joint effort to begin informing promising young scientists while still at this early stage in their education.



COSTUMERS AND COOPERATION PARTNERS SELECTION 2010

- Abbott GmbH & Co. KG, Ludwigshafen
- Adam Opel AG, Rüsselsheim
- Albany International, Saint-Junien (F)
- AL-KO THERM GmbH, Jettingen-Scheppach
- ante-holz GmbH, Bromskirchen
- Assénagon AG, München
- AUDI AG, Ingolstadt
- BASF SE, Ludwigshafen
- Bayer Technology Services, Leverkusen
- Biffar GmbH & Co. KG, Edenkoben
- Blue Order AG, Kaiserslautern
- BMW, München
- BPW Bergische Achsen Kommanditgesellschaft, Wiehl
- Brita GmbH, Taunusstein
- Burgmann Industries GmbH & Co KG, Wolfratshausen
- ClusterVision BV, Amsterdam (NL)
- DAF Trucks N. V., Eindhoven (NL)
- Daimler AG, Stuttgart
- DEG Deutsche Investitions- u. Entwicklungsgesellschaft, Köln
- delta h Ingenieurgesellschaft mbH, Witten
- Det Norske Oljeselskap ASA, Trondheim (N)
- Deutsche Bahn AG, Frankfurt/Main
- DEVnet Holding GmbH, München
- DLR - Deutsches Zentrum für Luft- und Raumfahrt, Braunschweig
- Dow Chemical, Freeport (USA)
- E.ON Anlagenservice GmbH, Gelsenkirchen
- EADS Deutschland GmbH, München, Ottobrunn
- EKF diagnostic GmbH, Barleben
- ESI Group, Paris (F)
- Evico GmbH, Dresden
- Universities of Applied Sciences: Darmstadt, Emden, Kaiserslautern, Mainz, Mannheim, Westküste, Südwestfalen, Trier
- Fleetguard Filters Private Limited, Pune (IND)
- FLSmidth Wadgassen GmbH, Wadgassen
- Freudenberg Forschungsdienste KG, Weinheim
- Geo Imaging Solutions INC, Houston (USA)
- Germanischer Lloyd SE, Hamburg
- Gesellschaft für Anlagen- und Reaktorsicherheit, Köln
- GKD Gebrüder Kufferath Düren, Düren
- GM/UM ABCD-Labaratory , Ann Arbor (USA)
- Görlitz AG, Koblenz
- Hamberger Sanitary GmbH, Rosenheim
- HAW Hamburg, Hamburg
- Hilite International, Nürtingen
- Hollingsworth & Vose, East Walpole (USA)
- IBS Filtran, Morsbach-Lichtenberg
- Institut de Radioprotection et de sûreté nucléaire, Saclay (F)
- Institut für Textil- und Verfahrenstechnik, Denkendorf
- International Partners in Glass Research, Bülach (CH)
- J. Eberspächer GmbH & Co. KG, Esslingen
- John Deere, Kaiserslautern, Mannheim
- Johns Manville Europe GmbH, Bobingen
- Keiper GmbH & Co. KG, Kaiserslautern, Rockenhausen

- Kömmerling GmbH, Pirmasens
- KTM-Sportmotorcycle AG, Mattighofen (A)
- Küttner Automation GmbH, Trier
- Laboratoire Réactions et Génie des Procédés, CNRS, Nancy (F)
- Landesbank Baden-Württemberg, Stuttgart
- Liebherr, Colmar (F), Kirchdorf
- Lotto Hessen, Lotto Rheinland-Pfalz, Koblenz, Wiesbaden
- MAGMA Gießereitechnologie GmbH, Aachen
- MAN Truck & Bus Deutschland GmbH, München
- MANN+HUMMEL GmbH, Ludwigsburg
- Marathon Oil, Houston (USA)
- Massachusetts General Hospital (MGH) / Harvard Medical School, Boston (USA)
- Millipore Corporation, Billerica (USA)
- NOGRID GmbH, Mainz
- Nonwovens Cooperative Research Center, Raleigh (USA)
- Oerlikon Neumag, Linz (A), Neumünster
- Optirisk Systems, London (GB)
- Papiertechnische Stiftung (PTS), Heidenau
- Paul Wild OHG, Kirschweiler
- proALPHA Software AG, Weilerbach
- Procter & Gamble, Schwalbach
- Progress Rail Inspection & Information Systems, Bad Dürkheim
- R+V Versicherung AG, Wiesbaden
- Reckitt Benckiser Produktions GmbH, Ludwigshafen
- Robert Bosch GmbH, Stuttgart, Waiblingen
- Roche Diagnostics GmbH, Mannheim, Pensberg
- RTT - Realtime Technology Aktiengesellschaft, München
- RWE Power AG, Essen
- S.D.R. Biotec, Pohritzsch
- SAR Electronic GmbH, Dingolfing
- Schmitz Cargobull AG, Altenberge
- Schott AG, Mainz
- Schottel Schiffsmaschinen GmbH, Wismar
- SIEDA GmbH, Kaiserslautern
- Siemens AG, Heidelberg, Nürnberg, Singapur
- Städt. Kliniken, Frankfurt-Höchst
- StatoilHydro Petroleum AS, Stavanger (N), Trondheim (N)
- Stryker GmbH & Co KG, Freiburg
- Teckpro AG, Kaiserslautern
- Tec-Sem AG, Taegerwilen (CH)
- Universities: TU Berlin, Bordeaux (F), Cambridge (GB), Dortmund, Dresden, Freiberg, Klinikum Heidelberg, Klinikum Homburg, Kaiserslautern, Karlsruhe, Kassel, Linz (A), Mainz, Mannheim, Nancy (F), Stuttgart, Ulm
- Vaillant, Remscheid
- Voith Paper Fabrics, Heidenheim
- Volkswagen AG, Wolfsburg
- Volume Graphics GmbH, Heidelberg
- Volvo CE, Göteborg (S), Konz
- VR Automotive Dichtsysteme GmbH, Auengrund
- Woltz GmbH, Wertheim
- Wyatt technology Europe GmbH, Dernbach
- Xi'an Typical Europe GmbH, Kaiserslautern

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Dr. Wilhelm Krüger, Blue Order AG

Kurt Lechner, Member of the European Parliament

Prof. Dr. Helmut Neunzert, Fraunhofer ITWM

Richard Ortseifer, Member of the Ministry for Economy, Traffic, Agriculture, and Viniculture in Rhineland-Palatinate

Ingo Ruhmann, Federal Ministry of Education and Research

Dr.-Ing. Jürgen Sauter, FE-DESIGN GmbH

Prof. Dr. Helmut J. Schmidt, President University Kaiserslautern

Dr. Mattias Schmidt, Procter & Gamble Service GmbH

Hans-Joachim Strüder, Landesbank Baden-Württemberg

Prof. Dr. Wolfgang Wahlster, German Research Center for Artificial Intelligence

Dr. Achim Weber, Member of the Ministry for Education, Science, Youth and Culture in Rhineland-Palatinate

Dr. Christof M. Weber, Daimler AG

FRAUNHOFER ICT GROUP

Shorter innovation cycles have turned IT knowledge into a perishable commodity. The Fraunhofer Group Information and Communication Technology (ICT) provides support in the form of customized solutions, consulting, and contract research for new products and services. The Fraunhofer ICT Group comprises 15 institutes as full members (among them also the Fraunhofer ITWM) and three associated members, representing a workforce of roughly 4000 employees and a yearly budget of approximately 205 Million Euros. Its central office in Berlin serves as a one-stop shop, referring customers to the appropriate contacts.

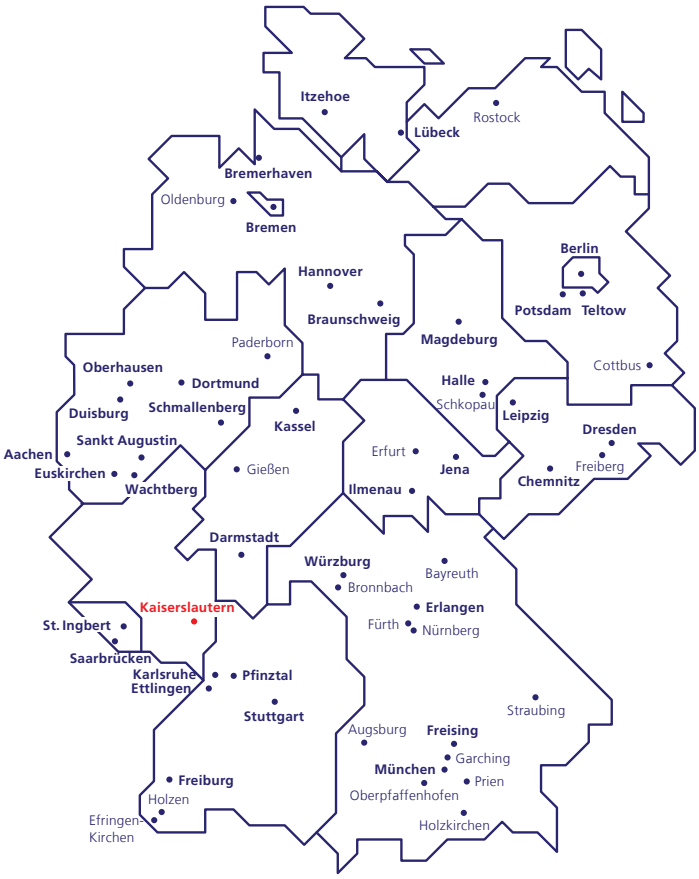
The complementary focal fields of the participating institutes cover the entire value chain of the ICT industry. The business areas are:

- Medicine
- Automotive
- Production
- Digital Media
- Energy and Sustainability
- Financial Services
- Security
- E-business
- E-government
- Information and communication technologies

The Fraunhofer-Gesellschaft is the largest organization of applied research in Europe. As a non-profit organization, it currently maintains approximately 80 research units – including 59 institutes – at more than 40 locations throughout Germany. A staff of approximately 17,000 employees – mainly qualified scientists or engineers – works for the annual research budget of 1,6 billion Euros. More than half of industrial profits stem from projects with small and medium-sized enterprises. The Fraunhofer-Gesellschaft deals with research and development projects ordered by economy, the state, and the public sector. International cooperation is supported by Liaison Offices in the USA and in Asia.

Research Topics of the Fraunhofer-Gesellschaft

- Adaptronics
- Construction Technology
- Energy
- Information and Communication Technology
- Medical Engineering, Environmental and Health Research
- Microelectronics
- Nanotechnology
- Surface Technology and Photonics
- Production
- Traffic Engineering and Logistics
- Defense and Security
- Materials and Components



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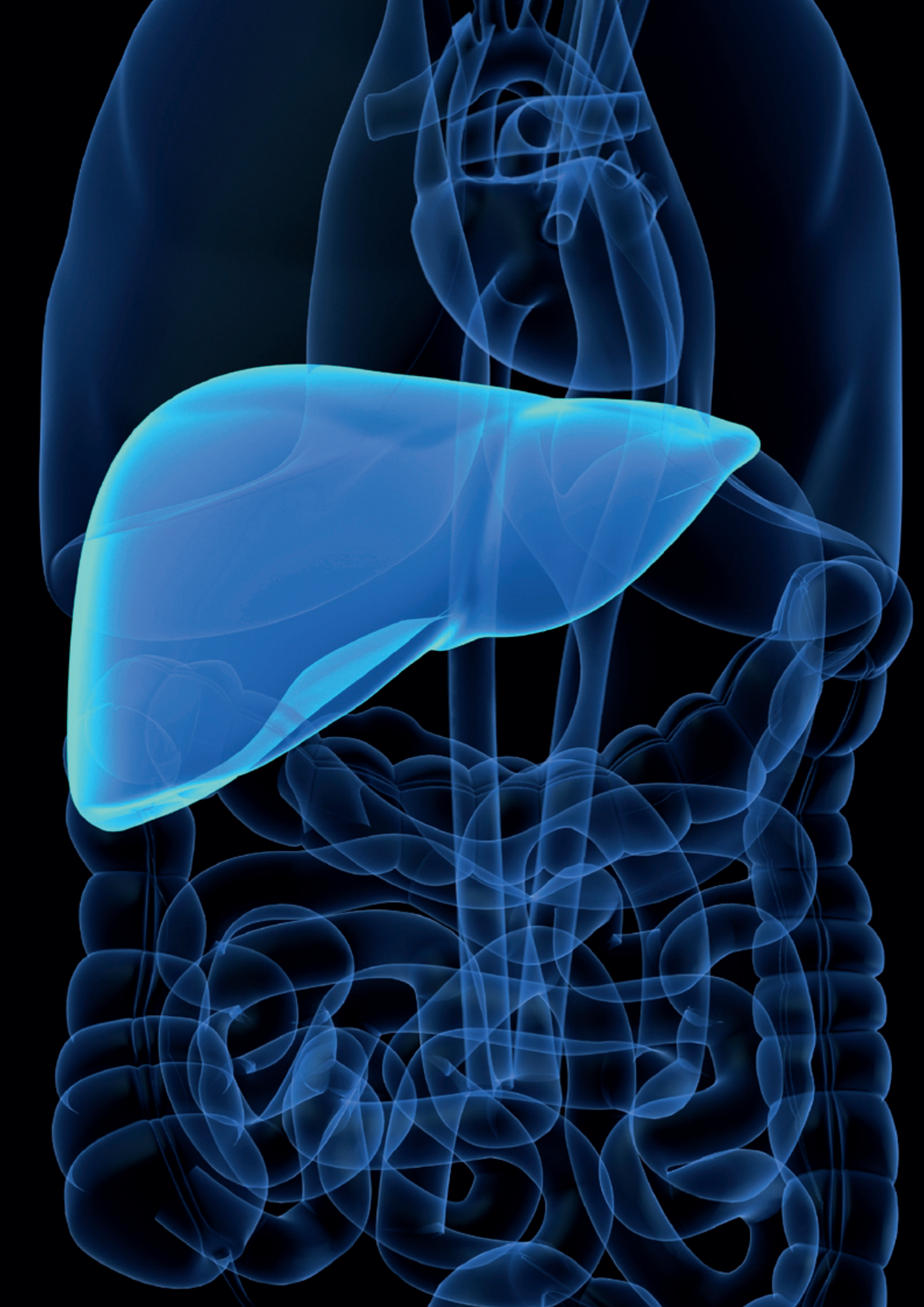

TRANSPORT PROCESSES

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

Head of Department
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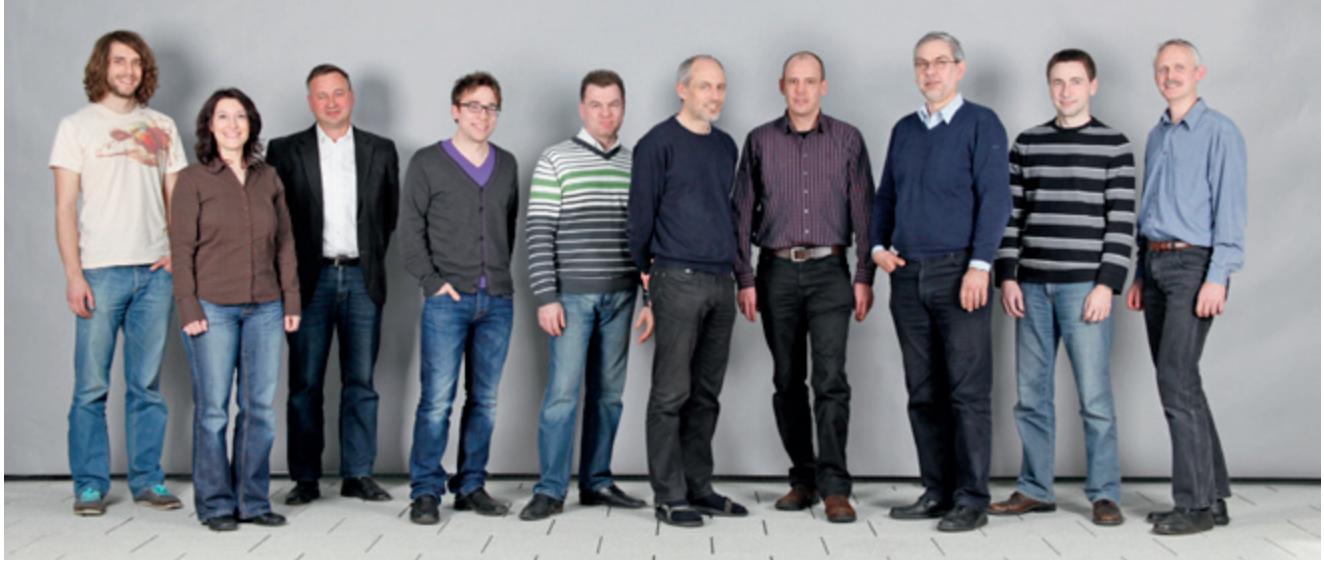


The main competency of the Transport Processes department is the mathematical modeling of complex problems in the engineering-natural sciences and the development of efficient algorithms for a numerical solution. Problems are addressed in areas like fluid dynamics, structural mechanics, radiative transfer, and optics and, from a mathematical perspective, can be formulated as partial differential equations. Our customers are primarily interested in the optimization of products or the technical design of production processes. The past year witnessed an economic recovery with a significant increase in contract research activity. The department welcomes the future optimistically with the successful acquisition of major strategic research projects.

Flexible Structures: This group developed FIDYST (Fiber Dynamics Simulation Tool), a software tool, which along with the corresponding studies of fiber and filament dynamics, is of great interest to customers in technical textiles and related machinery sector. ProFil (an alliance of five professors, three industrial partners, and ITWM as lead manager) is a BMBF funded project that promises to build an important foundation for an expanded range of applications in the coming years.

Fluid Dynamics: The focus of this group is to develop optimal dynamic flow solutions for our customers' requirements, many of which are currently in the area of mechanical engineering. We implement technological improvements based on fluid dynamic calculations (e. g., use of software tools like FLUENT) as well as mathematically optimal solutions, usually for appropriately simplified models.

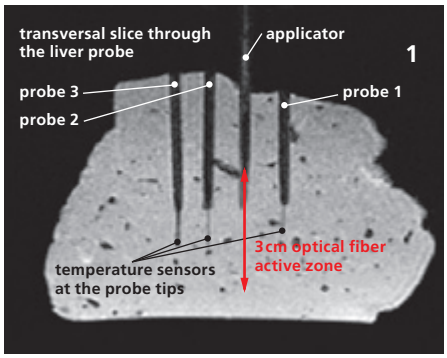
Grid-Free Methods: The department developed an in-house solver using the Finite Pointset Method (FPM) for a broad field of continuum mechanics with a major focus on the area of fluid dynamics. FPM is a meshfree method especially well suited for solving problems with variable time computational domains (multi-phase flows, free surfaces). The software is marketed and distributed by the company NOGRID.

Optics, Radiation, Heat: In this group we are pursuing the design of freeform lenses – a new, strategic subject with far reaching implications. A completely new type of algorithmic approach has been developed that is far superior to existing solutions and is now being expanded, implemented in production processes, and made into a marketable product by the strategic Fraunhofer project Freeform. The current design software will be distributed as a component of the LucidShape technical lighting software package by company Brandenburg in 2011. The group has its origins in projects that examined heat conduction and thermal radiation for cooling glass and is accompanied by projects for parameter identification and inverse problems, mainly in the glass manufacturing industry.

Model reduction: The creation of the MATLAB model reduction toolbox for large multi-physics FE systems was completed during the past year and has earned special recognition for its capabilities in parametric model reduction. The software developed has since been used in highly successful projects involving industrial contract research. The aim of future studies is to expand the range of application.

Johannes Schnebele, Dr. Simone Gramsch, Dr. Norbert Siedow, Daniel Burkhart, Sergey Antonov, Dr. Robert Feßler, Dr. Raimund Wegener, Dr. Dietmar Hietel, Jan Marburger, Dr. Jan Mohring
Christian Leithäuser, Dr. Jevgenij Jegorov, Dr. Ferdinand Olawsky, Dr. Jalo Liljo, Maria Friedrich, Dr. Matthias Schäfer, Johannes Maringer, Walter Arne, Thomas Cibis, Dr. Jörg Kuhnert

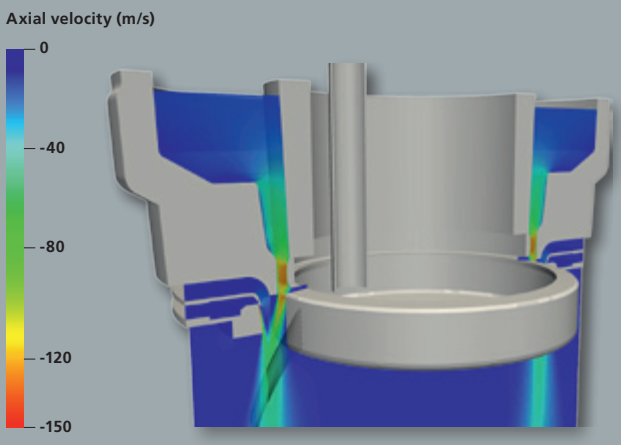
LASER INDUCED THERMOTHERAPY



1 *Experimental setup for LITT on pig liver*

The magnetic resonance controlled, laser induced, interstitial thermotherapy (LITT) is an established procedure in the minimally invasive ablation of various tumors. In a LITT procedure, the laser energy is delivered through optical fibers directly into the tumor which is destroyed by denaturation of the proteins. In order to control the coagulation of the tumors and to regulate the application of energy during the therapy, a display of the temperature curve during the therapy is essential. Magnetic resonance thermometrics and computer simulation can be used to plan, control, and regulate the LITT. A model that represents the practical steps in the LITT procedure was developed for the DFG project "In-vitro Temperature Determination and Computer Simulation of Temperature Distribution for Optimal Planning and Control of Laser Induced Thermotherapy." The energy input of the laser into the tissue is modeled by coupling radiation transport and heat conduction equations. The MR compatible laser applicator is water cooled, to prevent excessive tissue temperatures in close proximity to the applicator and to allow treatment of much larger tumors. The cooling effect is mathematically implemented by the boundary conditions of the heat conduction equation. The goal of forward simulation is to localize the time for the destruction of tissue by the heat energy generated by the laser. The destruction of the tissue cells is a chemical process that converts healthy liver and tumor tissue into coagulated tissue while taking the thermal history into account. The destruction function is described by the Arrhenius Law with the aid of activation energy and a frequency factor. Activation energy and frequency factor as well as the absorption and dispersion coefficients of the healthy and coagulated tissue are not well documented in current literature and vary from liver to liver.

One objective of the research project focuses on identifying the tissue parameters needed for the simulation with the aid of temperature measurement data. Because the solution of such an inverse problem requires repeated solutions to the immediate task at hand, in place of the high dimensional radiation transport equation, the P_1 approximation was used as an effective method of approximation. It has been demonstrated that both the coupled problems of thermal radiation as well as the adjoint system to identify parameters are uniquely solvable. In cooperation with radiology department of the University Clinic Frankfurt, using data obtained during a LITT procedures performed on pig livers, the biologic parameters at various times have been numerically identified.



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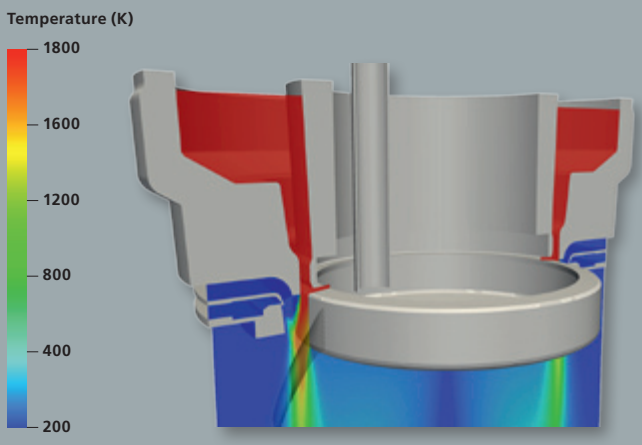

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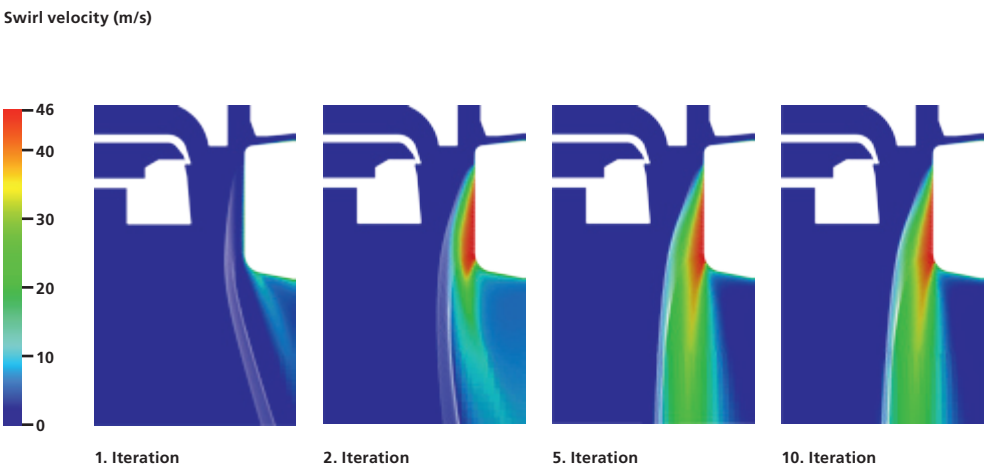
ROTATIONAL SPINNING PROCESS FOR FIBERGLASS INSULATION PRODUCTION

1 + 2 Rotational spinning process at Woltz: For illustration purposes, the 35 jets of a vertical column are shown as black lines. The colors illustrate axial speed and temperature of the air flow.

3 Illustration of iterative coupling: Swirl speed of an air flow with filaments (white curves)

The simulation and simulation based optimization of the manufacturing processes for fiberglass insulation requires an in-depth understanding of the rotational spinning of viscous jets, which are subject to strong aerodynamic forces. The rotational spinning process consists of two process steps: smelting and spinning. The facility type provided by our industrial partner Woltz Company in Wertheim is illustrated in Figure 1. Glass is heated to a temperature of 1050 °C. The molten glass is then introduced to a rotating centrifugal disk, which has perforated walls with 35 rows, each perforated with 770 holes. Driven by centrifugal forces, the molten glass is constantly expelled through these holes and, under the influence of viscosity, surface tension, gravitation, and aerodynamic forces, drawn into filaments. Basically, there are two types of air streams that interact with the viscous jets: Hot air warms the jets with a temperature of 1500 °C to keep them flexible and a fast moving, turbulent flow, which cools and stretches the filaments. The filaments are deposited on a conveyor belt and, after further processing steps, form the raw material for the fiberglass insulation. Regularity and the degree of stretching are key quality criteria for the end product.

The central problem for numerical simulation of this highly complex process is the coupled control of aero- and filament dynamics. A fundamentalist treatment of the problem as a dynamic, three dimensional, multi-phase problem of continuum mechanics is futile from the start as approximately 27,000 filaments are involved. This is the reason ITWM developed a suitable simulation setup, which models the fibers in terms of the Cosserat rod theory as a curve with associated balance equations (for mass, momentum, angular momentum, energy) and models the air



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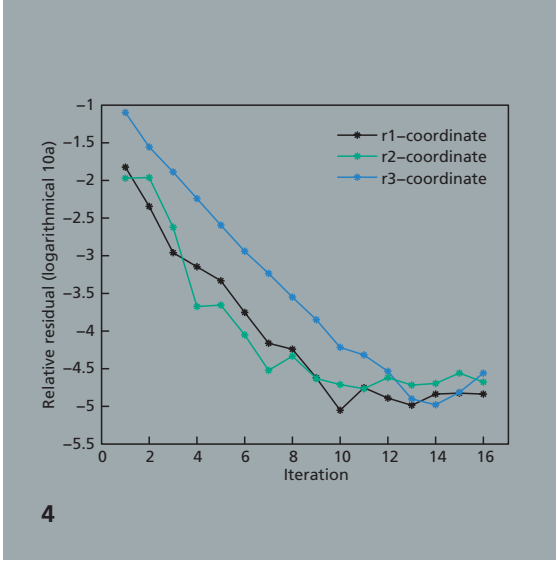

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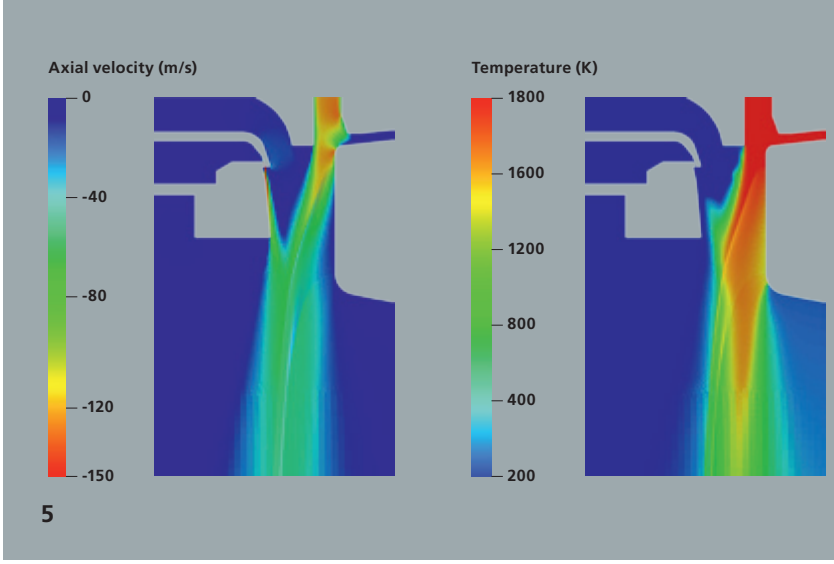


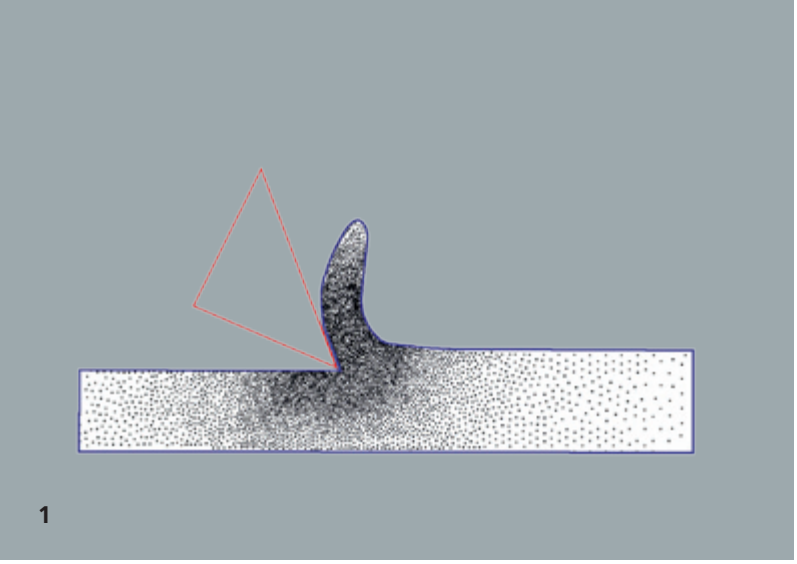
5

flow by expanding the Navier-Stokes equations with the appropriate string shaped sources. Subsequently, the rows are homogenized so that in the end calculation involves only 35 representative filaments – which behave as stationary objects in a rotating coordinate system – coupled with a rotationally symmetric flow. The coupling of aero- and filament dynamics is achieved through a new model for the air drag and a standard model for the heat exchange. This assures the principle of action/reaction as well as the retention of energy in the heat exchange between filaments and air.

The stationary filament dynamic based on the Cosserat rod theory can be stated as a boundary value problem with a given flow data. The solution uses a collocation/continuation method based on an appropriate MATLAB Solver, where a special in-house developed adaptive continuation strategy comes into play, which starting from moderate process conditions incrementally sets the actual production parameters. For the fluid dynamics, we use FLUENT with a UDF (User Defined Function) developed at ITWM, which allows the momentum and energy input to be entered through a given filament dynamic. The iterative coupling of these two Solvers, poses a special challenge for the efficient management of the simulation and coupling routines involved. In a preprocessing step, a finite volume grid is generated and access is provided to the FLUENT flow solver and to the boundary value problem solver that was generated in MATLAB. The coupled solution algorithm is then implemented with FLUENT as the master program. At the end of the flow simulation, FLUENT starts the MATLAB main program for filament dynamics. This in turn implements the parallel computation of individual filaments over MATLAB-Executables, with the available flow data being interpolated to the filaments. The MATLAB program collects data about each individual filament, averages across the cells of the finite-volume-grid and returns the data for realization to the coupling term in the UDF in FLUENT. The next step in the iteration begins with a second flow simulation. After just a few iterations, the results begin to converge. Figure 4 illustrates the L_2-convergence of the filament curve on a logarithmic scale, and figure 3 shows the so called swirl – the rotational component of the flow speed. Impressively shown here also is the strength of the drag effect of the filaments on the flow and, the absolute necessity to consider filament and fluid dynamics together. The final results for speeds and temperatures (figure 5) match very well with actual data observations.

4 *Convergence of iterative coupling algorithm; relative error of 35 representative filament curves in L_2-Norm*

5 *Final results for axial speed and temperature of air flow; Various colors of the extra filaments shows their convective transport speed and temperature.*



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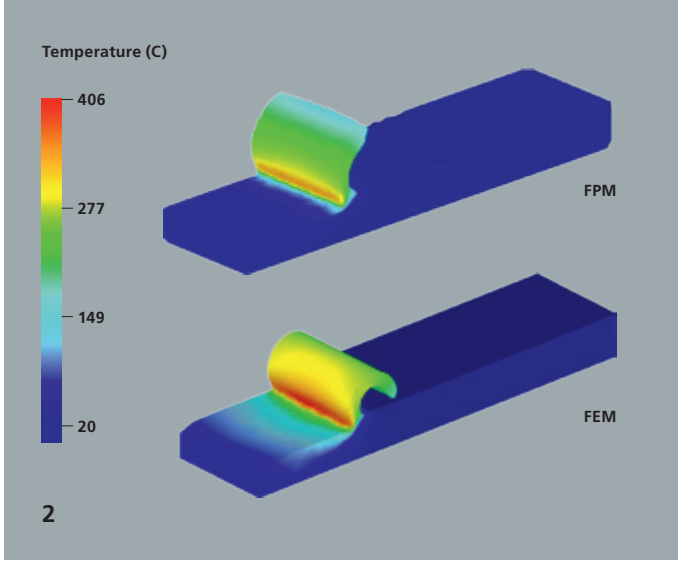

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CUTTING PROCESSES IN MANUFACTURING

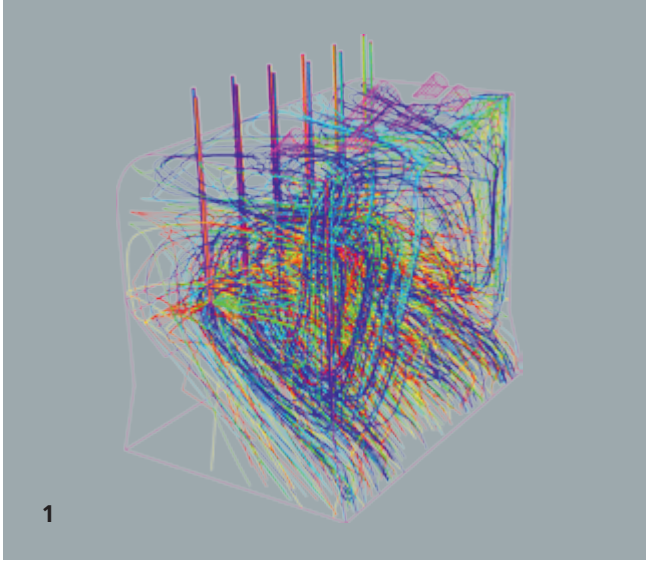
1 *Grid-free point configuration for the simulation of a machining process*

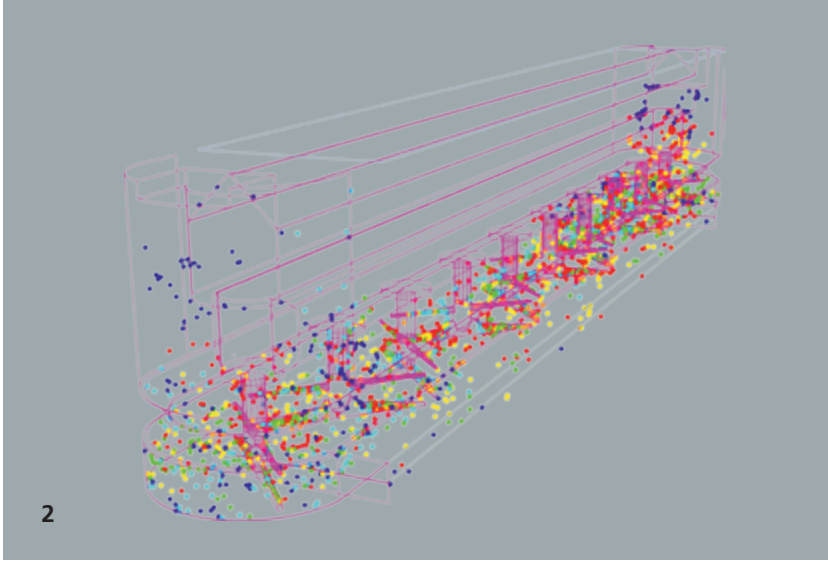
2 *FPM results compared to Finite Element Method (FEM)*

Cutting processes are used for almost every mechanically engineered product. Consequently, there is a huge optimization potential although the technical problems of interest here can vary greatly from case to case. It is possible to optimize the power consumption for a machining operation, but the same is true for other process characteristics like cutting force, cutting form, or wear and tear on the tools. Another consideration is the guarantea of product properties, for example, problem definition involving post machining residual stress, surface structure, micro structure, burrs, etc. The criteria mentioned above are primarily adjusted empirically, in effect, the machining operation is manually adjusted at the machine until the process and the product satisfy the required properties. This was the fastest and least complicated process available until now. Simulation tools in the area of machining processes are not presently in widespread use in industrial environments, rather they are principally found in research-engineering situations.

A simulation based optimization on an industrial scale would be a great advantage as it would expose all machining processes down to the smallest detail (plastic deformation, material failure, chip/burr formation, thermal strain, internal stresses, etc.) and would allow very effective adjustments in the machining processes. This implies a high capacity computer model. ITWM is performing joint research with Institute for Machine Tools and Factory Operations at the Technical University of Berlin and has the support of the German Science Foundation (DFG) to work on a simulation method for cutting processes in manufacturing that would satisfy the requirements mentioned above better than previous methods. Such a simulation is based on the so called Finite Pointset Method, a method developed in continuum mechanics at ITWM, which has already been used successfully in the areas of airbag inflation, glass forming or tank/silo filling. The method is meshfree and is therefore very efficient in processes with free surfaces and moving geometry parts.

To date, the work has been to adapt FPM Solver to the dynamic behavior of metallic materials. In the next stage, the main effort will be on the coupling of the different phases. For example, besides the work piece, the tool should also be integrated as a phase in the simulation. Eventually, the cooling fluid should also be modeled as an added phase to achieve a much more realistic picture of the cooling and performance behavior in the cutting processes.





AIRLAID PROCESS FOR NON-WOVENS

The airlaid process of the company Neumag uses turbulent air flows that ensure the most uniform distribution possible as short fibers and granulate particles are deposited onto a conveyor belt. This is achieved in two steps: First, the fibers and particles are blown into the so called chamber, a space with a turbulent air flow within for blending. The mixture then flows into so called rotor cases positioned directly above the belt and fitted with numerous mechanical rotors to further homogenize the mixture. The rotors are installed in horizontal rows at intervals directly above the belt and rotate about the vertical axis. The undersides of the rotor cases are made of large mesh screens which allow the short fibers to be suctioned from the rotor cases and deposited onto the belt.

In order to simulate this process, FLUENT calculates the air flow together with the particles fed into the flow. These are described as point particles with mass and drag coefficients. They move independently from one another according to equations of motion for point particles. Because of the rotating blades, the geometry of the flow area is variable in time, so that a transient flow simulation must be performed on a time variable grid. Finally, the distribution pattern on the belt resulting from several different particle types, all differentiated by mass and drag coefficient, is determined. There are significant differences based on the particle type and non-uniform distributions are the result.

In a subsequent optimization phase, the geometries of the chamber and the rotors, specifically, the rotor blades were modified such that the optimal uniformity of the resultant deposits on the belt was achieved. In order to gain a better understanding of the problem and proceed in a deliberate manner, the problem was divided into several parts. First, the chamber was modified to ensure that the best possible distribution of the short fibers is achieved in the air flow supplied to the rotor cases. Then, to facilitate the examination of the effect of the rotors, just one single rotor was studied. Subsequently, the combined effect of all the rotors in the rotor cases was examined and optimized.

1 *Particles paths in the chamber; different colors to visualize the kind of particle.*

2 *Particle distribution in a rotor; different colors to visualize the particle size.*

FLOW AND MATERIAL SIMULATION

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

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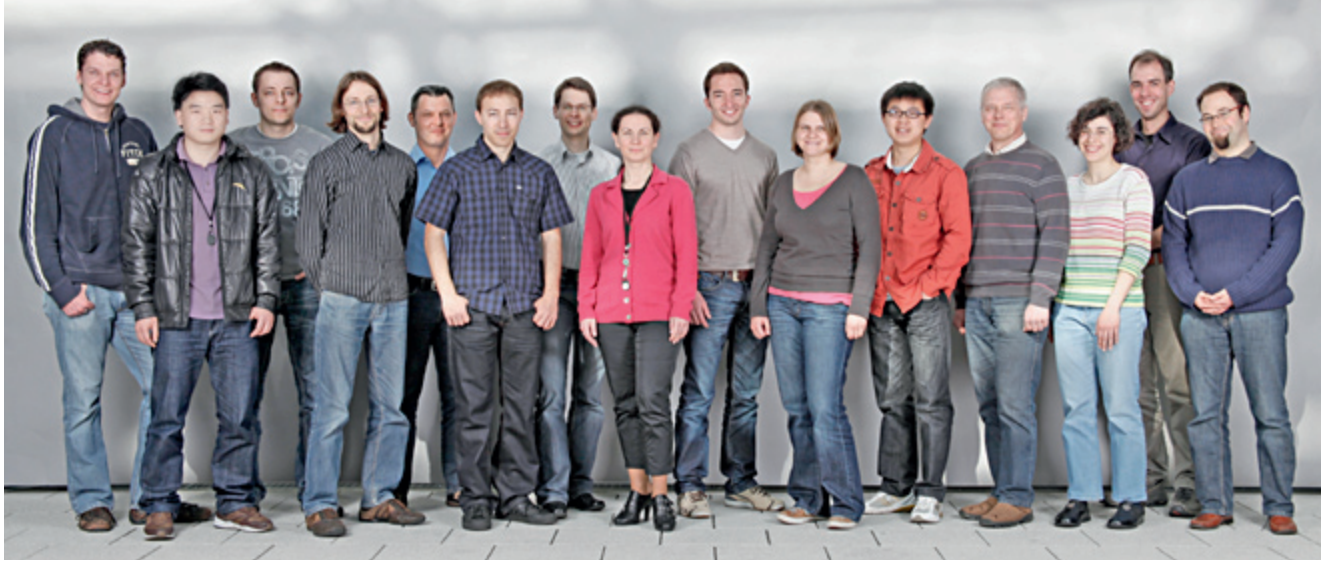


The department works on multi-scale modeling and the development of efficient and robust simulation methods and software tools for the integration of virtual material design into product development. Models and simulations of the manufacturing processes of complex composites or hybrid materials are being integrated more and more in the virtual design process. The expertise in development, provision, and specific use of multi-scale and multi-physics methods suitable for industrial application make this department quite unique.

The Microstructure Simulation and Virtual Material Design Group created GeoDict, a software package that can now realistically generate all major heterogeneous material structures like packed beds, dens packings, textiles, and composite materials. On this basis, the interrelated structural properties like permeability, filter efficiency, diffusion coefficients, thermal conductivity, and elasticity can be quickly and efficiently calculated. A good example is the current study of capillary properties in porous non-wovens or paper.

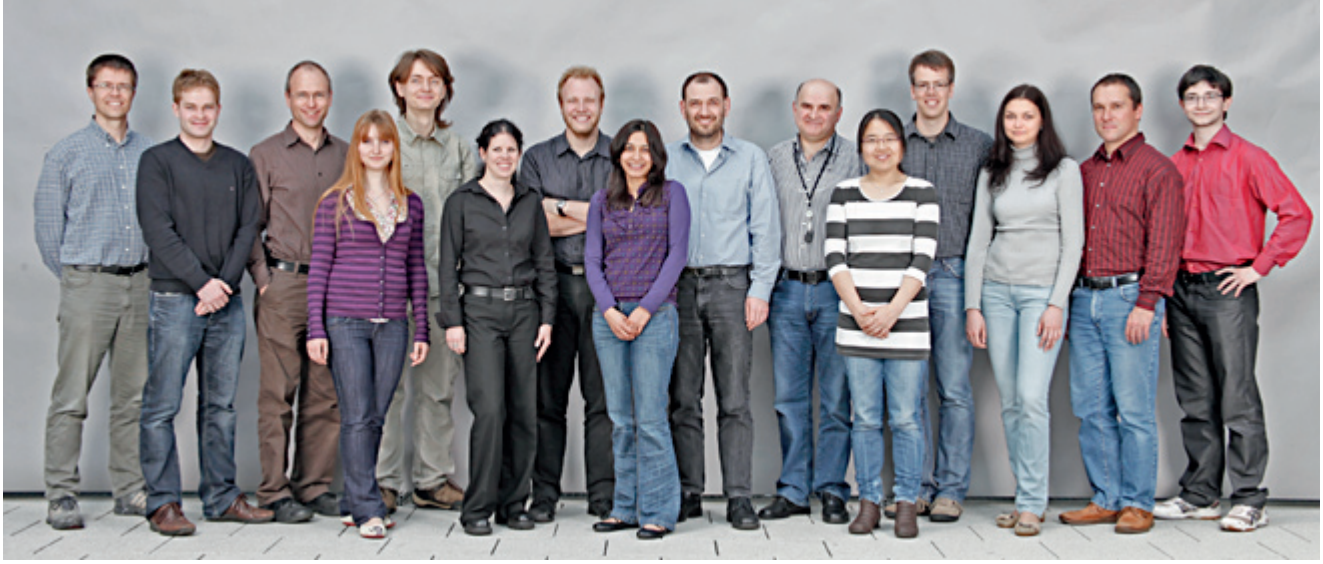
The Hydrodynamic Development Group is focused on efficient numerical processes and customized software solutions for multi-scale flow simulations. Current projects include: filter element design (SuFiS), the optimum filter pleat design (OptPleat), the optimum design of microfluidic equipment, and flood simulation and local risk management for urban areas (RisoSim) or for reactor accidents (CoPool).

The CoRheoS software platform of the Complex Fluids Group bundles numerous modeling and simulation solutions for the description of multiphysical phenomena of composites, granulates, fibers, or particle suspensions. Our current practical applications include: the transport and mixing of powders and granulates (CoRheoGrain), powder technology injection molding processes (CoRheoPol) as well as the production of reinforced fiber components (CoRheoFiber), or the manufacturing of high performance battery materials (BEST).

At the Mechanics of Materials Group, we examine the thermo-mechanic and acoustic designs of complex composite structures and porous material composites in their specific applications. Our variable, extensible finite-element-software "FeelMath" is currently being used to perform very efficient micro-mechanical design studies of reinforced fiber plastic components and fiber materials like non-wovens or paper. Other applications can be found in the biomedical field.

The very positive growth from project and business revenues continues, both absolutely and as a percentage. The customer relations were strengthened and new, long-term industrial joint ventures were successfully initiated. The desired staff growth desired was only marginally possible, but at least we attracted an adequate number of PhD candidates to work on diverse research topics. The repeated high level of departmental success is primarily attributed to the outstanding efforts and motivation of the staff. The broad network at all levels of research was further expanded: Collaborative research projects with the mathematics and engineering sciences departments at the TU Kaiserslautern have been intensified through the new Innovation Center for Applied System Modeling; the first Fraunhofer Multi-Physics Conference was jointly organized through the Fraunhofer Simulation Alliance; and, international contacts became much closer than ever before, especially with Texas A&M University and the year-long visiting scientist program for this year's Fraunhofer-Bessel-Prize winner, Prof. Yalchin Efendiev.

Tobias Zangmeister, Shiquan Zhang, Dr. Dariusz Niedziela, Dr. Erik Glatt, Dr. Ralf Kirsch, Sven Linden, Dr. Matthias Kabel, Inga Shklyar, Marco Buck, Cornelia Kronsbein, Xingxing Zhang, Dr. Aivars Zemitis, Dr. Katrin Roberts, Dr. Jochen Zausch, Stefan Frei, Dr. Andreas Wiegmann, Clement Zemerli, Priv.-Doz. Dr. Arnulf Latz, Tatiana Gornak, Edward Toroshchin, Sarah Ricker, Dr. Sebastian Schmidt, Dr. Zahra Lakdawala, Dr. Konrad Steiner, Prof. Dr. Oleg Iliev, Dr. Liping Cheng, Dr. Jürgen Becker, Galina Printsipar, Dr. Stefan Rief, Tigran Nagapetyan

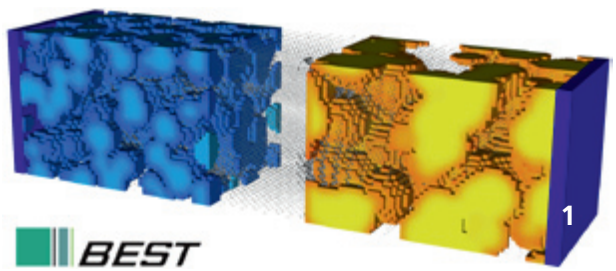


MODELING AND SIMULATION OF LITHIUM ION BATTERIES

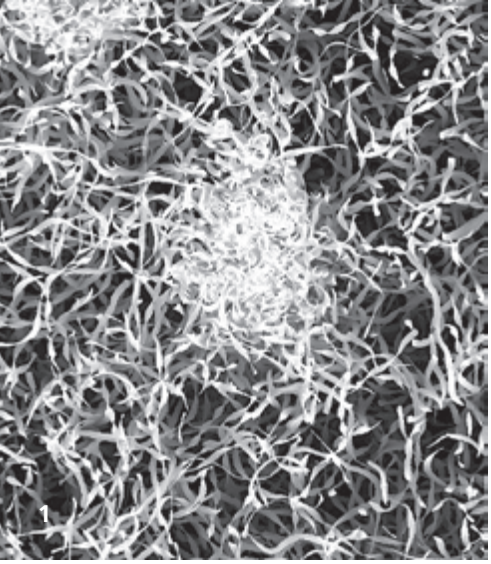
In order to reduce the release of green house gases into the atmosphere, alternative concepts for energy production are required. In particular automobile industry seeks for new technologies to substitute the classical combustion engine. Hence, in recent years electromobility has become increasingly important. Electronic vehicles draw their power from rechargeable batteries – mainly lithium ion batteries. However, for automotive applications the demands with respect to capacity, power, life-time and safety on these batteries are high and more development is needed in the field of electrochemical energy storage.

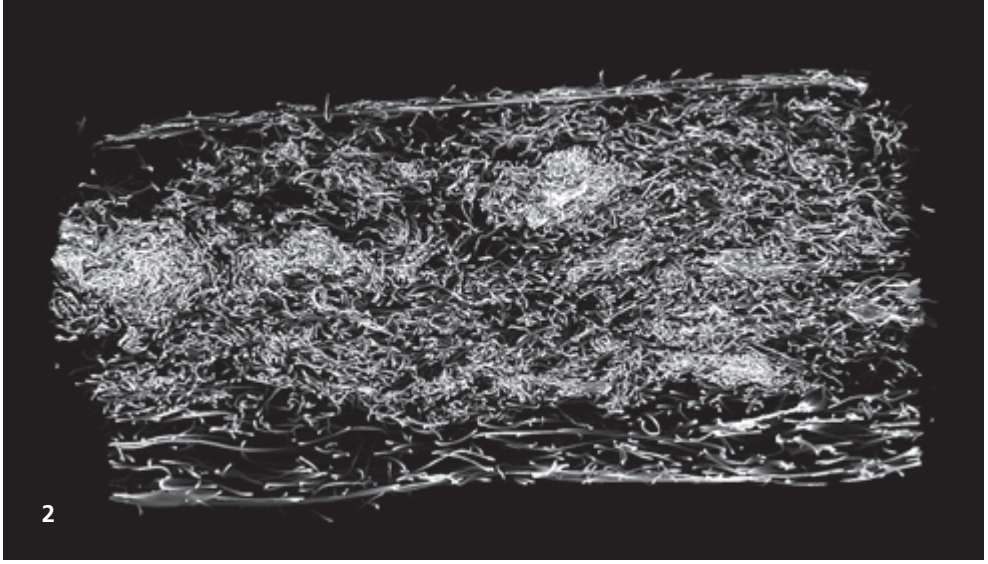
In the framework of the project "Fraunhofer Systemforschung Elektromobilität FSEM" funded by the government, 33 Fraunhofer institutes collaborate to promote development in many fields of electromobility. The ITWM is working in the work package "energy storage" on the development of new materials for lithium ion batteries by physical modeling and numerical simulation.

A lithium ion battery consists of two electrodes and an electrolyte filled separator in between. The electrodes exchange lithium ions through the electrolyte. For the performance of the battery not only the material parameters of the involved materials are relevant but also the microscopic structure of the electrodes are crucial. Within FSEM the ITWM is developing the finite-volume solver "BEST – Battery and Electrochemistry Simulation Tool" for meso- and microscopic battery simulations. Since the implemented models are based on the underlying electrochemical processes, it is possible to calculate not only macroscopic observables like e. g. voltage curves but also, for instance, the three-dimensionally resolved distribution of the lithium ion concentration within the battery cell. This can facilitate a deeper understanding of the limiting factors for a given battery. Therefore, computer simulations help to optimize material composition or electrode geometry with respect to a given target with low effort. Also new design ideas can be tested and characterized with ease.



1 *Cross section through a simulated, generic battery with anode particle (left) and cathode particles (right). Shown are lithium ion concentration (color scale) and current flow (arrows).*





WATER TRANSPORT IN CELLULOSIC MATERIALS

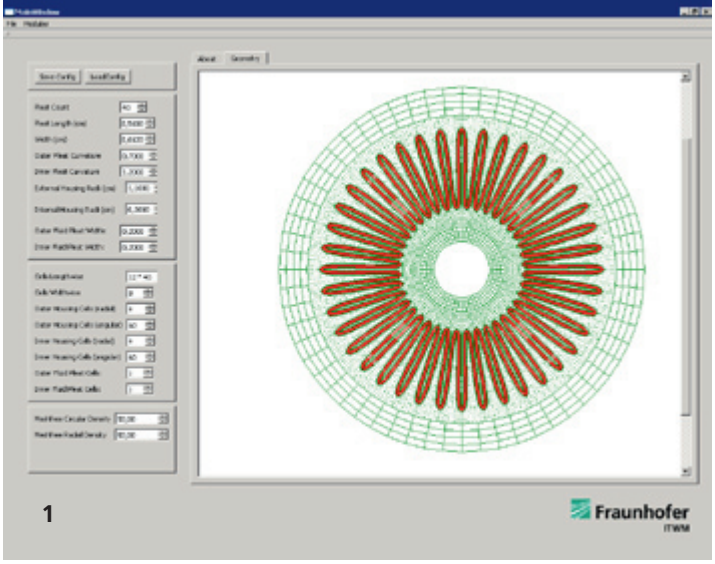
1 *GeoDict created model of the cellulose fiber layer with an inhomogeneous distribution of fibers*

2 *Cross-section of the CTscan: the cellulosic material is located between two fibrous layers on top and bottom.*

It was the aim of this project to determine numerically the effective transport properties of a cellulosic layer. This fibrous layer is one of many different layers used in modern hygiene products to control and steer the flow of a liquid. To improve the functionality of this product, it is very helpful to know the permeabilities and capillary pressure-saturation curves of all the different materials and layers used. Computer simulations allow to determine these parameters and thus enable to engineer new materials virtually.

To capture the structure of the cellulosic material samples, three-dimensional computer tomography images were taken. These 3d images were segmented and thus three-dimensional geometric structure models of the layer were obtained. By using ITWM's software tool GeoDict directional and saturation-dependent permeability and capillary pressure curves were calculated on these models. Here, the main difficulty is the size of the tomographic images. A single 3d image may consist of up to 4000^3 voxels, i. e. may require 60 GB!

However, the determination of material parameters based on CT scans is only the first step, as it only allows to investigate already existing materials. To study the impact of possible material variations on the product, virtually constructed structure models are needed. GeoDict allows to create these model. In this project we investigated, how the inhomogeneous fiber distribution influences the transport properties. For this, structure models with an uniform fiber distribution were compared to structure models with fiber agglomerates.



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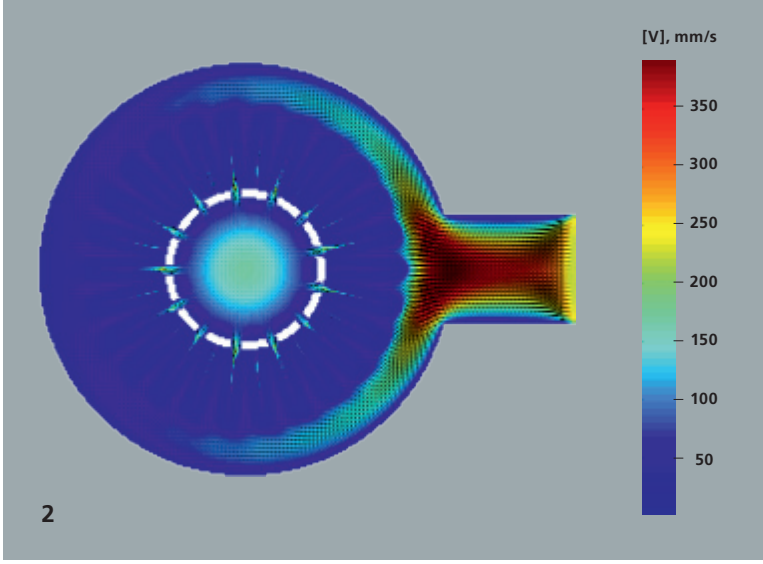


2

SIMULATION AND OPTIMIZATION OF PLEATED FILTER MEDIA

OptPleat is a recent development of Fraunhofer ITWM, started in 2010. It is designed for computer aided predictions of the complex processes in filter elements with pleated filtering media.

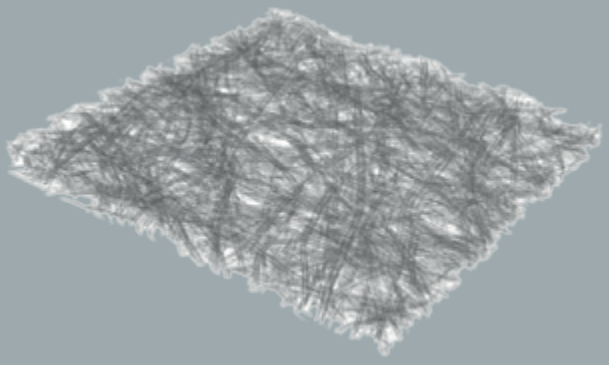
Due to their favourable filtration surface to filter housing volume ratio, pleated filters are widely used in various fields of industrial, medical, and municipal applications. The simulation of pleated filters involves huge challenges due to the complex shape of the filtering medium and the resulting impact on both the flow field and deposition of particles. Computations using standard methods are very cost ineffective. OptPleat, utilizes problem-adapted and robust algorithms that are specially designed for the class of pleat filters to reduce the computational costs and thereby their design and development time.

OptPleat includes a graphical user interface to enable the user to modify his/her own pleated filter in an interactive way: the housing along with the number and shape of the filter pleats can be modified with simultaneous visualization of the geometry. It further facilitates the management of input data. The modular structure of OptPleat enables the user to choose an appropriate tool for the given optimization task, depending on the complexity of the problem at hand. For example, an initial optimization of the shape and filtering medium can be performed using very fast routines based on analytical solutions for the deposition profile. For further improvement of the design, there is a toolbox for the simulation of flow and filtration in 2d and 3d. In addition, standardized filter efficiency tests (ISO) can be simulated such that OptPleat offers a large variety of optimization possibilities long before the stage of real world prototype begins.

Research and many numerical investigations have shown the importance of the impact of deformation of elastic porous medium under the influence of flow. Therefore, in one of OptPleat's modules, it considers the fact that the loading of the filtering media results in changed permeability which further results in changed pressure drop and eventually new/deformed shape of the pleats. The adequate consideration of this complex interplay between deposition, deformation and flow is crucial for filter designs with lesser risks of "pleat collapse". This module is one of the key subjects of the current and future development of OptPleat.

1 *GUI for modification of the geometry of the filter medium*

2 *Pressure distribution and flow field inside a filter element with pleated medium*



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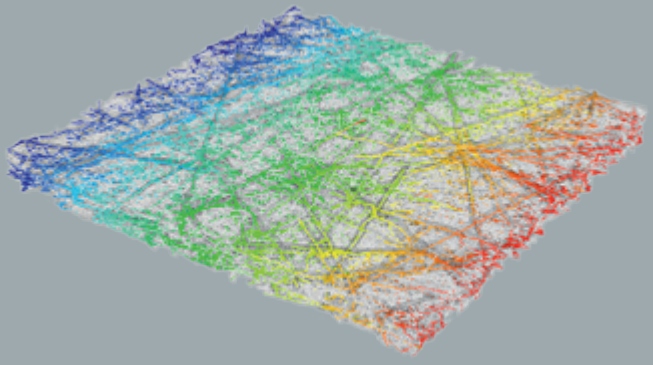


2

INNOVATIVE SIMULATION OF PAPER (ISOP)

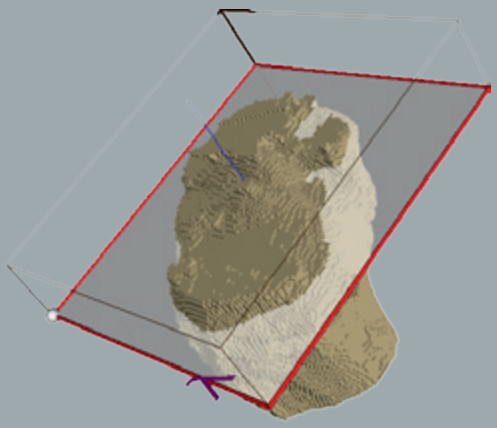
1 *X-ray tomography revealing the microstructure of paper (sample size: 2 mm × 2 mm)*

2 *Deformation of the fiber network under tensile load*

Although paper seems to be homogeneous to the human eye, an X-ray tomography reveals, that it has a fibrous structure on the microscale. To perform simulation of paper microstructure to predict paperboard properties represents a new approach to product and process development in paper industry.

To this aim we together with scientists from Albany International, Eka Chemicals, Stora Enso, Tetra Pak and Fraunhofer-Chalmers Centre (FCC) started the development of a new modular software ISOP based on enhancements of existing software packages. First, we extended GeoDict by a paper microstructure model (PaperGeo) which analytically describes the geometry of the fiber network. Secondly, we integrated beam models to simulate fiber deformations and sophisticated algorithms for the contact detection of huge fiber networks to the FEM elasticity solver FeelMath. The next step will be the combination of these tools with the FCC flow solver IBOFlow by the end of 2011, using the in parallel developed ISOP-interface. Then it will be possible to analyze and optimize the process of paper manufacturing as well as quality control with respect to paper composition. Due to the generic approach, this technology can be also applied to any other fibrous products like textiles and nonwovens.

The first structural mechanical quality control that was simulated within the project is the bending resistance, described in detail by the Scandinavian pulp, paper and board testing committee (SCAN-P 29:95). To be more precise, the bending resistance of a paperboard is calculated in two steps: First, a stochastic geometry-model of the microstructure is generated with PaperGeo using parameters of the cellulose fiber (density, length distribution) and of the papermaking process (grammage, thickness of the paperboard). Secondly, with FeelMath the contacts between the cellulose fibers are detected and properly modeled. Afterwards, homogenization of the fiber geometry yields the tensile stiffness of the paperboard. This is used to calculate the bending resistance on a macroscopic level. Each step of this procedure has been validated by extensive measurements of the industrial partners. The Fraunhofer ITWM developed advanced beam models to simulate the production of non-wovens (FIDYST - Fiber Dynamics Simulation Tool), fiber networks and together with FCC the structural dynamics of cables (IPS Cable Simulation).



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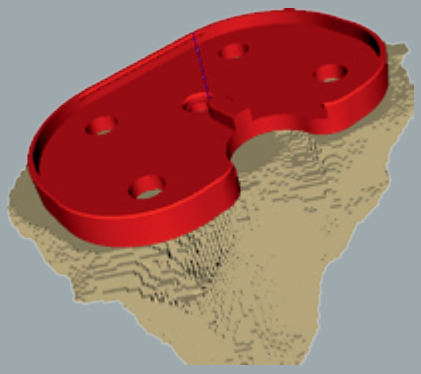

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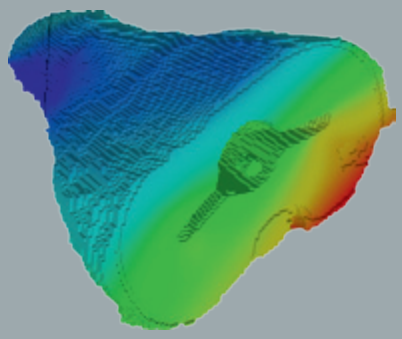

3

BIOMECHANICAL SIMULATION SOFTWARE FOR PLANNING OF KNEE PROSTHESIS

Knee prosthesis is put in as an artificial knee joint when there is an advanced wear and tear or in case of extreme destruction of joint surface. Due to the individual size and the different internal structure of bone, a surgeon's task is among other things to choose a suitable prosthesis and to find the optimal position for it relatively to the bone. Since a surgeon is not able to try out all prosthesis directly on the patient, they have to be tested virtually by computer simulations. Such algorithms and software packages are developed at the Fraunhofer ITWM together with scientists from Catania (CCC) and Lima-Lto spa (Italy).

The goal of this project is to develop methods and algorithms in cooperation with doctors, engineers and mathematicians, which improve the choice and the positioning of prosthesis and make it easier, in order to improve patient's quality of life. Such models have to consider individual characteristics of patient's bone and prosthesis. These characteristics are considered in biomechanical models by specific material laws and their parameters. Especially the contact zone between bone and prosthesis is of great importance. The local mechanical strain produces biological stimulus, which lead to bone building, that means to the merging of prosthesis. High accurate models are developed for the analysis of this zone, which consider the microstructure of the surface of the prosthesis and bones. The so called mechanical contact problems for the prosthesis-bone system are solved numerically by the finite element method. High accuracy in the simulation can only be achieved, if the triangulation of bone and prosthesis is fine enough. Fine meshes lead to huge linear systems of equations, in this case with millions of unknowns. The solution for those linear systems is essentially accelerated by domain decomposition methods, which are developed especially for (cost-effective) parallel and multiprocessor machines. Consequently, numerous variants can be simulated in a short period of time.

A graphical user interface should help the surgeon to realize virtually the operation of bone and the positioning of prosthesis and to test the mechanical strain of the prosthesis-bone system per computer simulation. Such virtual operations can be performed several times with no pain for the patient, in order to make the best decision.

1 *Selection of the cut surface for the tibia bone*

2 *Selection of the size of the tibia plate*

3 *Deformation of the tibia bone under typical compression (simulation of a jump)*

IMAGE PROCESSING

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

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Kaiserslautern is recognized as an important center of image processing, because of the continuing and reliable work of the department. This is evident by the many appointments to major committees, e. g., the coordinating council of the Fraunhofer Vision Alliance and the advisory board of the Heidelberger Image Processing Forum. The department is also the first stop for other users within the Fraunhofer-Gesellschaft for issues of image processing. For example, ITWM is the top address in the Fraunhofer Building Innovation Alliance for image analysis challenges. The appointment of Gabriele Steidl to a Professorship for "Image processing and data analysis" on the Faculty of Mathematics at TU Kaiserslautern effective in January 2011, is especially gratifying and further strengthens this location. This appointment is expected to bring new scientific impulses to Fraunhofer ITWM.

Numerous joint ventures with domestic and foreign research institutes were continued last year with the aim of accelerating the practical use of research results. The cooperation with the French Ecole des Mines in Fontainebleau, the civil engineering department at TU Kaiserslautern, the Darmstadt University, and the University of Linz all proved to be especially productive.

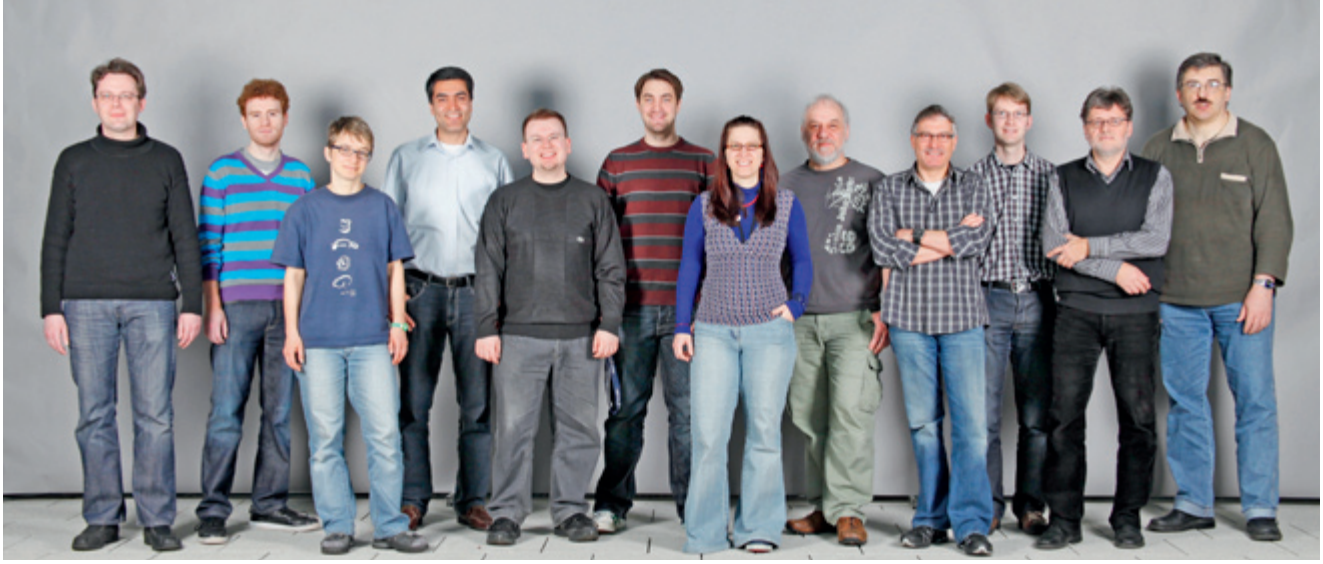
The department's customer base consists primarily of small and middle size companies. The innovative projects with local business, for example, Wipotec Weighing Technology and AVID (formerly Blue Order) are particularly gratifying. Major corporations like Abbott and BASF also belong to the ranks of our regular customers. In this way, opportunities arise to strengthen regional industries with the aid of modern image processing methods. Combined with the latest mathematical methods, many years of experience in the development of algorithms for industrial image processing, especially in the area of quality assurance, come together in solving the most diverse inspection challenges. Classic image processing like edge enhancement or covariance analysis are used along with efficient algorithms for determining extreme values in high dimensional space or for assessing similarities in images and image sequences.

The signal analysis group for the railway sector has a long standing record of cooperation with GE Transportation Systems. After the acquisition of the Inspection Products Divison in 2010 by Progress Rail and the establishment of the new company Inspection and Information Systems (PRIIS), the way was open for new innovative systems in railway control technologies. Fraunhofer ITWM is the perfect partner for all algorithm and software development needs.

Fraunhofer ITWM is known for its high performance algorithms and software. MAVI has been in place as a user friendly software for the analysis of 3d volume images of micro or nano structures for several years by now. ToolIP is an innovative, in-house developed graphic algorithm development tool that simplifies the design, testing, and optimization of algorithmic chains for 2d and 3d image processing tasks. Originally developed as an internal "toolbox" for high reliability algorithmic components for inline applications in the area of surface inspections, ToolIP now enjoys growing interest from external customers. We are responding to this demand with additional algorithms and improved operability features for 2011.

Naturally, the image processing department was not immune to the effects of the financial crisis. In spite of this, the revenue from industrial projects reflected significant increases in the last two years, especially, as a result of an increased number of projects in the second half of 2010.

Thomas Redenbach, Björn Wagner, Andreas Fink, Henrike Stephani, Kai Taeubner, Thomas Weibel, Alina Kuznetsova, Behrang Shafei, Dr. Ronald Rösch, Thomas Eckert , Irene Vecchio, Sebastian Hubel, André Liebscher, Andreas Jablonski
Markus Rauhut, Erwin Kraft, Dr. Katja Schladitz, Dr. Ali Moghiseh, Michael Godehard, Torben Prill, Rebekka Malten, Franz Schreiber, Dr. Martin Spies, Dr. Stephan Didas, Hans Rieder, Martin Braun



MASC SOFTWARE LIBRARY AND TOOLIP

The creation of image processing algorithms for visual inspection systems is a complex and costly challenge. Many different filters, classifiers etc., are connected in a processing chain so that the surface faults to be detected can be automatically identified by an inspection system. The designers of image processing algorithms must frequently combine, parameterize, and test a large number of methods. To make their work easier, the image processing department developed the "MASC Software Library" with a graphic development environment called "ToolIP". ToolIP enables image processing algorithms to be programmed graphically. The algorithm is modeled as a graph, in which the algorithms are the nodes of the graph and the edges represent the data flow. The basis is a library with approximately 300 different algorithms:

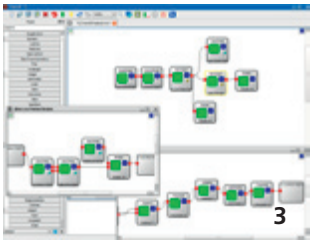
- Basic operations for images (load, save, transform image)
- Image enhancement and de-noising (linear filters, morphological filters, rank filters and adaptive anisotropic filters)
- Edge detection (Canny, gradients, Sobel, Laplace, Hessian Matrix, Hough Transform)
- Object recognition (similarity measures, template matching)
- Image registration (statistical similarity measures)
- Image segmentation (adaptive threshholding, local neighbors)
- Local features (mean values, variance, entropy, texture descriptors, and local geometry)
- Classification (linear discriminants and Mahalanobis distance classifiers, support vector machine, clustering)
- Matrix operations (SVD, QR decomposition, inversion, value and vector calculations, and algorithms for PCA and ICA)

Besides the simple programming using a graphic surface, modeling of the image processing algorithm as a graph provides an additional advantage. Borrowing standard algorithms from graph theory, executing the image processing is made much faster by automatic parallelization. Furthermore, the software independently recognizes how many processing cores the executing computer has and optimizes the algorithmic accordingly. Also, because this is an automated process, the parallelization cannot result in errors in the software. All basic algorithms are implemented in C++, with graphs saved as XML files. This enables the high performance execution of the software. In the simplest case, a graph may be executed using a C++ method with the SDK provided. Every routine in the MASC Software Library can be integrated and executed as a normal C++ function in other software. Moreover, it is also possible to expand the library with in-house processes.

1 Standard view of ToolIP

2 Parameter dialog of ToolIP

3 Sections of a graph can be combined into a sub-graph to provide a clearer overview of the algorithm.



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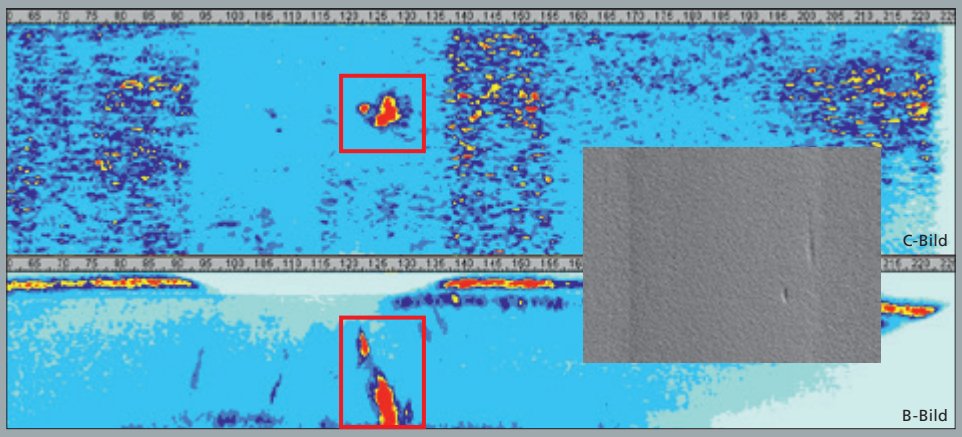


2

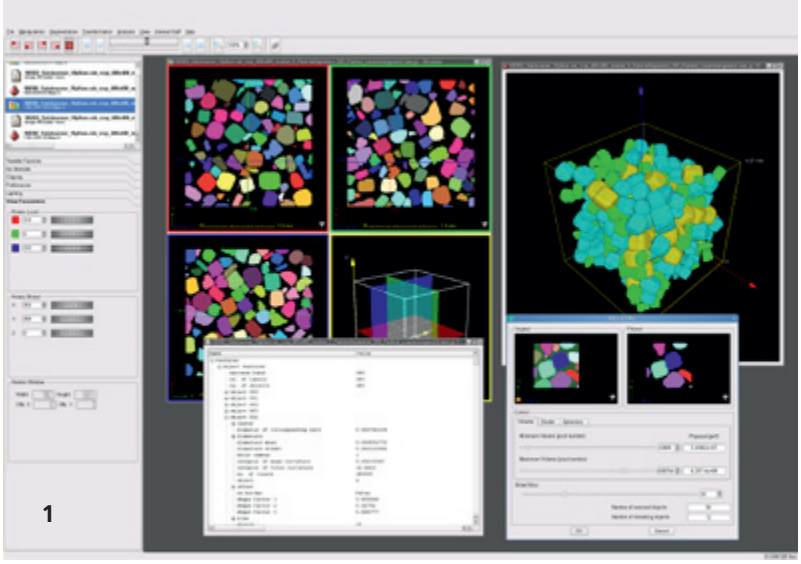
IMAGING ALGORITHMS FOR ULTRASONIC INSPECTION OF LONGITUDINALLY WELDED LARGE PIPES

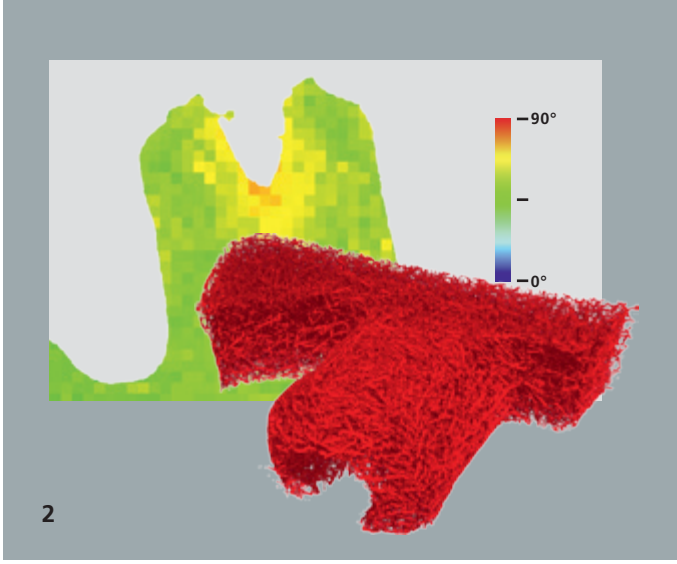
1 Semi-automatic mechanised inspection of welds in large pipes

2 Combination of the SAFT-based imaging of a slag inclusion; the defect indications are marked by the red boxes. For comparison the X-ray image is shown (in different scale).

The manufacturing of large steel pipes is performed in a complex process. The three essential mechanical process steps are U-forming, O-forming and expanding. Along the whole length and width the steel plate will be pressed and formed to a U- and then to an O-shape which will finally be expanded. Before expanding, which determines the correct dimensions and the final radius, the pipe will be welded along the whole length. The quality of the welds will be examined before and after expanding using nondestructive testing. The first step of this inspection consists of automatic ultrasonic testing. In a second step, the welded joint will be additionally examined by X-ray technique, if ultrasonic testing results with relevant indications. In case of existing doubt due to the extracted results, the defects will be manually inspected for analysis purposes using a manual ultrasonic system. Contrary to manual ultrasonic inspection, mechanised inspection offers some essential advantages due to the quality of detection and reproducibility. For the inspection of large pipes at Europipe's manufacturing site in Mülheim, the Salzgitter-Mannesmann Forschung GmbH (SZMF) has built up a multichannel ultrasonic inspection system to detect and characterize defects inside the weld. An essential part of the system consists of the two imaging methods TOFD (Time-of-Flight Diffraction) and SAFT (Synthetic Aperture Focusing Technique). The algorithms are used for post-processing of the raw ultrasonic data and are well suited for efficient interpretation of the ultrasonic signals.

The main objective of the joint project was the development and validation of the ultrasonic inspection system, including enhanced imaging techniques to be applied in the manufacturing process. The set-up uses a mobile scanning system and a specific ultrasonic inspection system with different program modules for data acquisition, imaging, visualisation and manipulation. The advantages of the selected concept are due to the polymorphic hardware, the modular build-up and the implementation as an open hardware and software system. Due to this open concept, the customer has access to all interfaces which implies the possibility to integrate modules from his own sources. Moreover, the system can be expanded by further well-suited modules and components. The ultrasonic system is suitable for lab and industrial applications. Support and maintenance will be performed by Fraunhofer ITWM; the imaging group uses the same ultrasonic system e.g. for the inspection of ship propellers. Further developments of Fraunhofer ITWM are as well available for customers. The imaging group also provides support in view of the theoretical background of ultrasonic NDT. The performance and efficiency of the system and of the imaging algorithms were examined and validated together with SZMF and Europipe on a large number of test specimens with well-defined defects. ITWM's imaging group has further methods available which can be similarly applied for improvement of ultrasonic inspection of industrially relevant materials and components.





MAVI 1.4 – NEW ALGORITHMS FOR 3D-IMAGE ANALYSIS

In 2010, the image processing department released version 1.4 of its volume image processing, analysis and visualization software MAVI. Typical sources for these 3d-data are µCT or FIB/(s)TEM, to name a few. MAVI allows to characterize the geometry of a microstructure in terms of volume density, specific surface, density of the integral of mean curvature and of the Euler number. Furthermore, derived quantities allow e. g. to judge the anisotropy of a material ("field features"). When combined with MAVI's image segmentation methods, it is also possible to measure individual objects. These measurements enable the creation of statistics such as distributions of object shape and object size ("object features"). A module for model-based 3d-analysis of open foams has also been part of MAVI for several years ("open foam features").

With the release of MAVI version 1.4., recent developments regarding the local analysis of materials ("subfield features") and the analysis of fiber directions ("subfield fiber directions") have now been transferred to this product. These modules allow the user to map measurement results back to the image space, a functionality which is often useful for an interpretation of the results, and to measure the directional distribution of fiber systems. These new features are particularly well suited for the analysis of fiber reinforced polymers, as demonstrated below.

Glass Fiber Reinforced Polymer

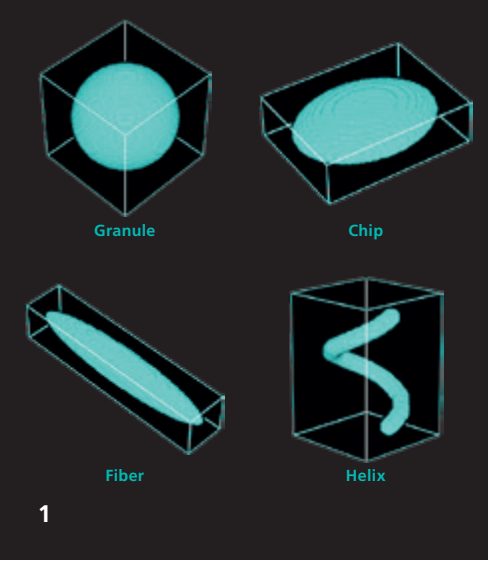
A small section (approx. 6 mm) of a glass fiber reinforced polymer specimen was imaged at Fraunhofer ITWM using X-ray µCT at a spatial resolution of 6.7 µm. In a first step, the fiber system was segmented, yielding an average fiber volume density of 15.3 %. The local variations around this mean value can be visualized using MAVI 1.4. The spatial distribution depicted therein can be said to be homogeneous. A different judgment should be made when considering the local deviations of the fiber directions from the z-axis. This illustration, created using MAVI's "subfield fiber directions"-module, shows differences of up to 30°, especially in areas with strong concavities in the specimen's shape.

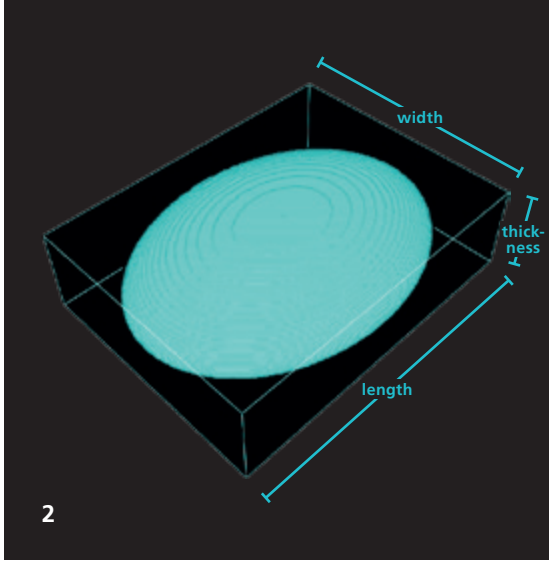
Hence, MAVI 1.4 extends the scope of 3d-image analysis to the important area of fiber reinforced lightweight construction materials.

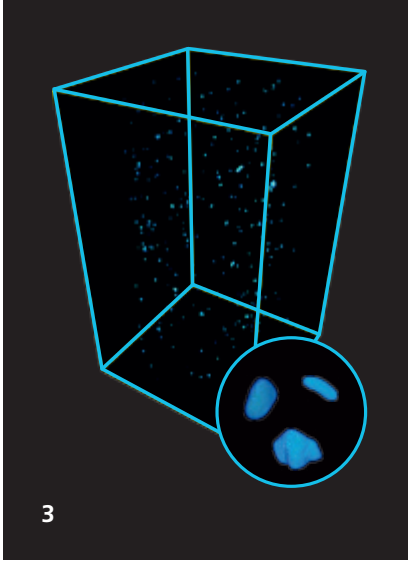
1 Screenshot of the MAVI software package

2 Glass fiber-reinforced polymer specimen. Volume rendering of the fiber system and results of local fiber direction measurement (angular deviation from the z-axis). Strong deviations occur especially close to the specimen's concavity.

MAVI
Modular Algorithms
for Volume Images







3D PARTICLE CHARACTERIZATION FOR TECHNICAL CLEANLINESS

1 *Types of particles*

2 *Ellipsoid with minimum volume bounding box, size of a particle in 3d*

3 *Three dimensional rendering of a sample of real particles*

Technical cleanliness is a key issue in a variety of application areas, in particular in the automotive industry. During the production, residual dirt collects on the surface of mechanical parts, thus affecting the durability and reliability of the assembled product. Therefore, it is of particular importance, to inspect the status of cleanliness of the components during the production. For this purpose, industries have to comply with agreed international standards, in which techniques to measure and to reduce the presence of dirt on the components are thoroughly described. However, these analyses are solely based on two dimensional microscopic images. Thus the analysis methods must become more sophisticated, as the required accuracy in production grows. Micro-computed tomography offers the opportunity to image thousands of dirt particles simultaneously in 3d. The contaminating particles are collected on a filter membrane, which is subsequently rolled up. That way, the complex shapes of the particles are captured completely.

Within this project, methods to classify particles on the basis of their three dimensional shape will be developed. The first step consists in determining which morphological parameters exhaustively define the shape of a particle; subsequently, efficient algorithms to estimate them based on 3d image data will be implemented and tested on real datasets. Mainly, 3d objects can be distinguished into three classes: fibers or needles, whose length is much larger than the radius of the cross section, chips, flat particles, and granules, for which all the three dimensions are comparable. Hence the size of a particle is the first feature we consider. In 3d, it is defined through the measure of the edges of the box bounding the particle such that its axes are arbitrarily oriented and its volume is minimal. Comparing the ratios of these measures, a classification as above is easily performed. Although such measures allow to correctly classify most of the particles, for some it fails, e. g. a fiber rolled around a helix (fig. 1). Thence other parameters, independent from the size, will be taken into account. Here, the three isoperimetric shape factors are suitable candidates. They are defined as suitably normalized ratios between volume and surface area, volume and mean width, surface are and mean width, respectively. These numbers convey the idea of how similar is the shape of a particle to a sphere.

For the largest particles the geodesic length is calculated additionally. That is, the measure of the longest geodesic path between two points in the particle. In the case of the twisted fiber, it corresponds to the length of the medial axes and thus yields additional evidence, that the particle is fiber-like. Within this project, which is a cooperation with the RJL Micro&Analytic, a new version of MAVI, MAVIparticle will be produced and merchandised. The tool is characterized by the possibility to perform the complete analyses of a sample, from segmentation via calculation of geometric parameters and classification of particles to visualization of the largest or most dangerous particles.

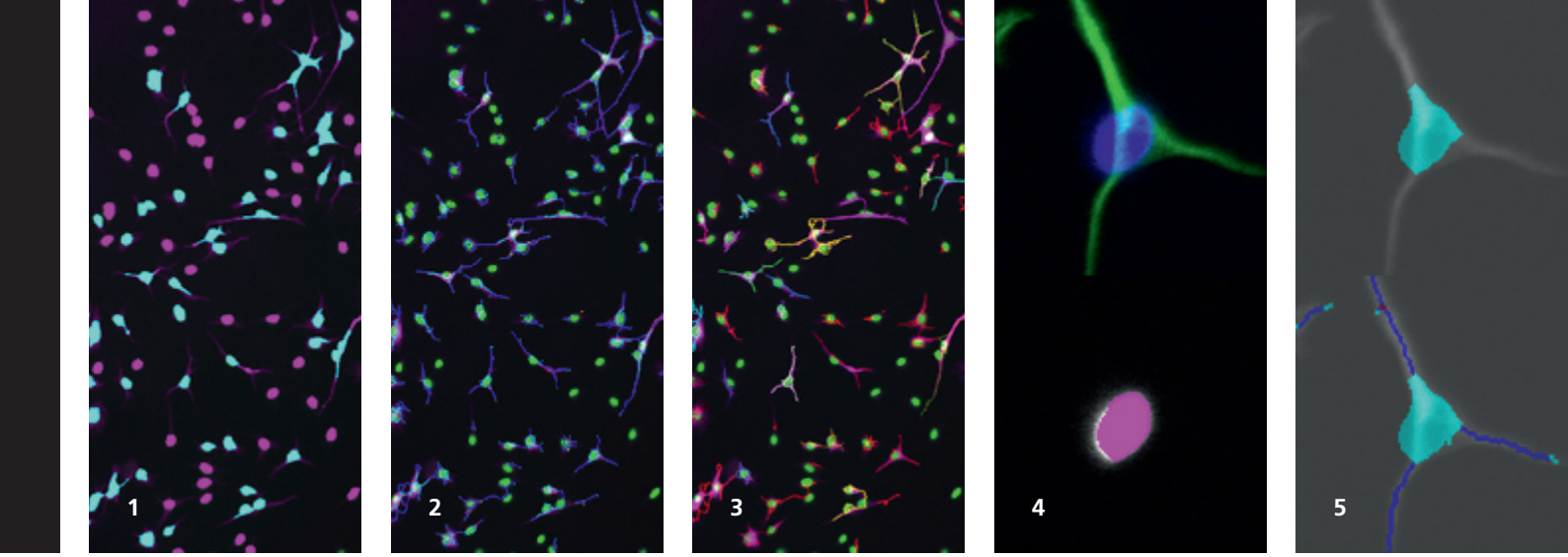


IMAGE ANALYSIS IN THE PHARMACEUTICAL INDUSTRY

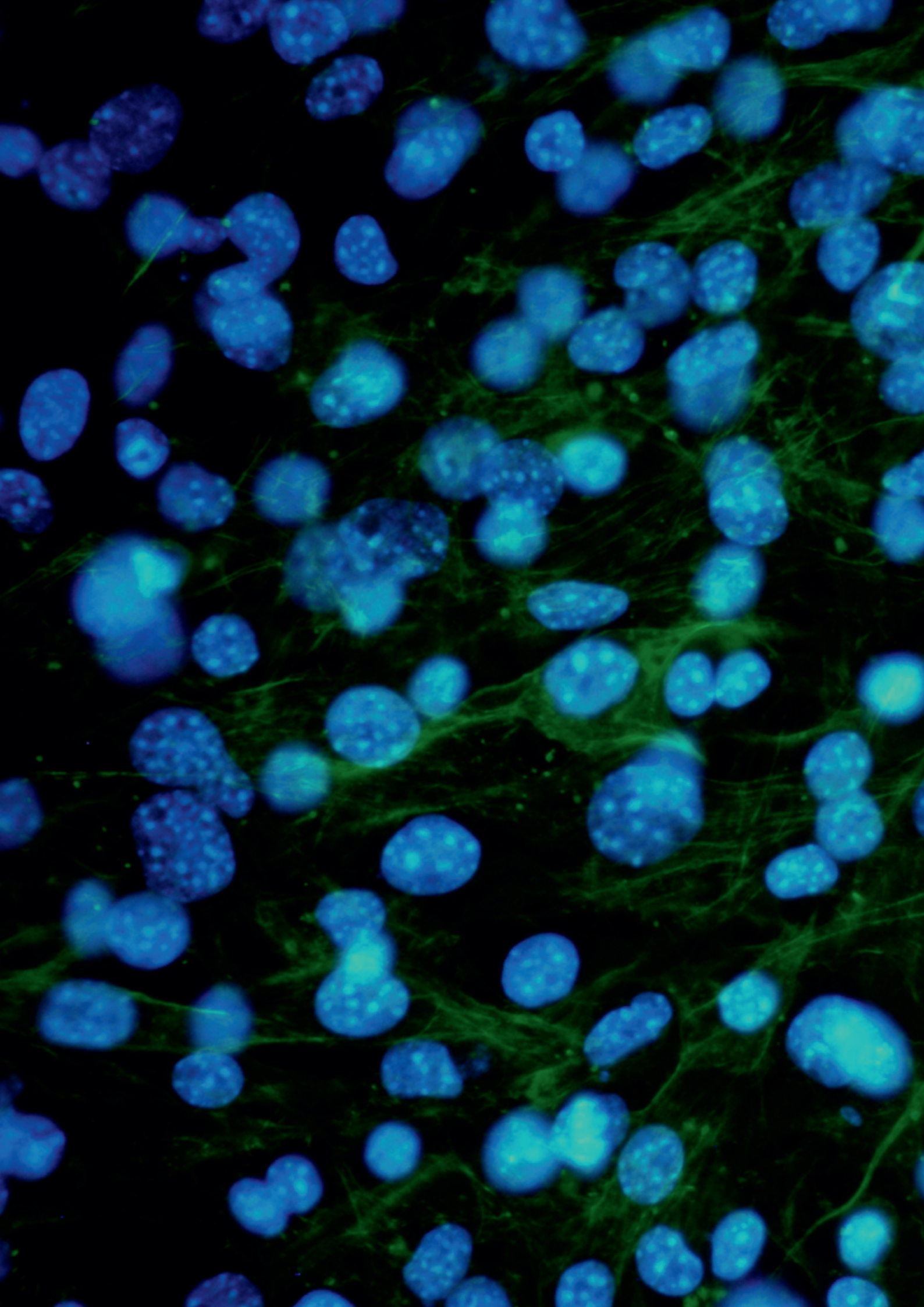
In the pharmaceutical industry the development of substances for so-called targets (specific biological structures) plays an important role in the search for new medicine. Research departments in the pharmaceutical industry are constantly looking for new targets, showing interaction between the biological system of the body and a chemical substance. For instance for the development of new medicine to treat psychiatric and neurological diseases for which it is known that intensive medical care is needed. Typical diseases are schizophrenia, depression, hyperactivity/attention disorder and neurodegenerative diseases including Alzheimer and spinal cord and brain trauma. Nowadays, the aim is not only for symptomatic treatment but also for treatment of the actual cause of the disease.

Since the beginning of 2007 the department "Image processing" is in cooperation with one of the leading pharmaceutical companies in the southern part of Germany. As part of this close collaboration the ITWM takes care of the quantitative and qualitative analysis of measurement data being acquired by different image acquisition systems such as fluorescence and laser scanning microscopy. The aim is a reliable detection of the interaction between different substances in cell cultures or tissue sections. For the automated image processing a variety of 2d- and 3d-image analysis routines is being used. The high variance in the data acquisition process, the diversity of the cell cultures and the work with natural structures makes this task a real challenge.

A typical application is the detection of growth in nerve cells. The induction of neurite outgrowth in neuronal-like cells in culture represents a functional mechanism predictive of neuroregenerative efficacy. An algorithm has been developed which for different case studies is able to measure and quantify this growth for different cell types and varying treatments. In a first step the single nuclei are being detected by a multi-level segmentation process. Based on these nuclei the neuronal cell bodies are being detected using a conditional growth process. As a final step the neurite outgrowth is being measured by growing localized background elements towards the neurite skeleton using a watershed strategy. The watersheds describe the neurite growth starting from the neuronal cell bodies in a tree structure with segments of different order.

1–3 *Examples of treated cells: definition of the cytoplasmic area showing nuclei and neurites; identification of neurite-like growth for each single neurite; classification of cells with neuronal-like morphology and growth*

4+5 *Detection of neurite outgrowth: original data showing two image layers; detection of the nucleus; growth of the nucleus into the cell body; identification of neurite outgrowth using a watershed strategy*



SYSTEM ANALYSIS, PROGNOSIS AND CONTROL

- DYNAMIC HETEROGENEOUS NETWORKS
- MONITORING AND CONTROL
- DECISION SUPPORT IN MEDICINE AND TECHNOLOGY
- PROGNOSIS OF MATERIAL AND PRODUCT PROPERTIES
- MULTISCALE STRUCTURE MECHANICS

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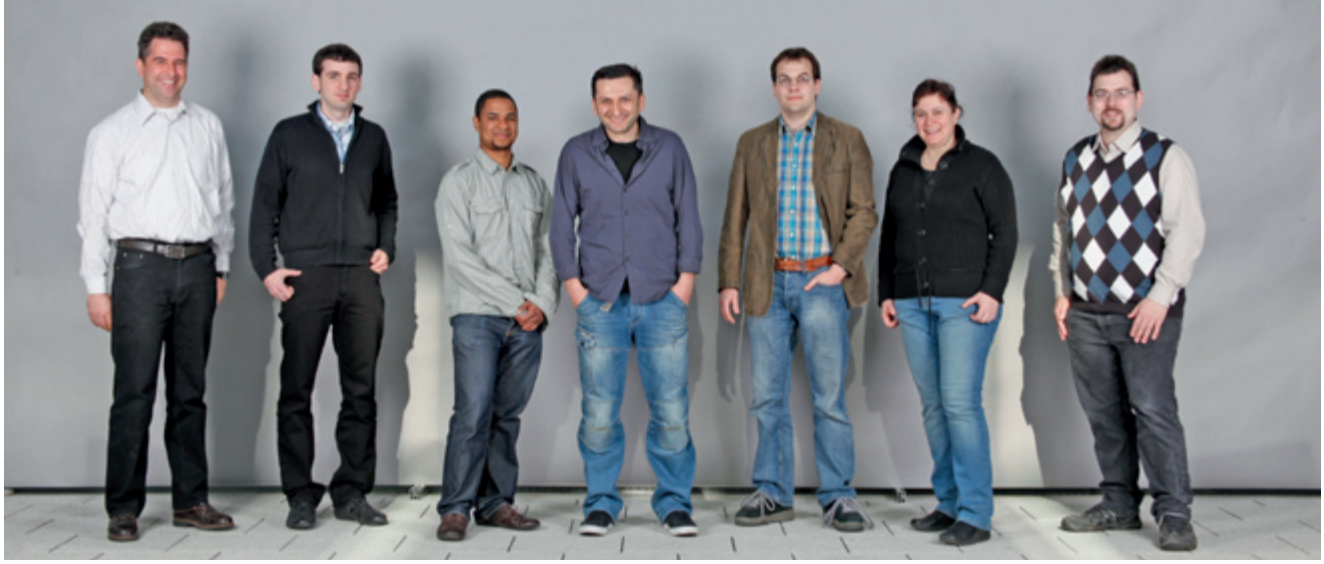


Technological applications and industrial processes are becoming more complex all the time and, by their very nature, biological systems are highly complex. Nevertheless, the interest is great – even when a detailed system model is often only possible to a limited degree for reasons of complexity – in being able to predict and control the system states. This is precisely why the department is developing methods based on measurement data and expert know-how that enable an enhanced understanding of the systems as well as highly reliable forecasting and control over future system behavior. In addition to its own products, the department provides complete consulting services and customer-specific software development.

The research focus of the group Dynamic Heterogeneous Networks is modeling and analysis of complex networks. Error-controlled mixed symbolic/numeric model reduction methods yield an in-depth system understanding and enable efficient simulations. In the report period, besides the continued development of algebraic methods for verification of digital systems, new functionalities were integrated in the departmental product Analog Insydes. A new release of this symbolic EDA software for transient analysis and model reduction of nonlinear electronic devices was prepared: "Analog Insydes 2011".

In the area of Monitoring and Control, activities are focused on model based control and observer design. Robust control strategies, iterative learning control approaches, model predictive control, and neuronal control each have a methodical role to play. Current projects are studying fracture monitoring in rotary machinery, especially in turbine generator shafts at power plants, and thermal process controls.

The mission at Decision Support Systems in Medicine and Technology is to provide support to the complex diagnosis and decision making processes. Multivariate statistical methods, time series analysis, data mining, fuzzy logic, and graphic exploration techniques are used. Current projects are concerned with the development of suitable data mining methods as a service component in modern business processes and manufacturing software as well as the automated analysis of information and medical telephone consultation services.

In the area Prognosis of Product and Material Properties, models based on measurement and simulation data methods are used for prediction, classification, and simulation. An enhanced system understanding can then be generated using the appropriate analytical approaches. Applications using this method now focus on forecasting the durability parameters of exhaust systems, the prediction of adhesive properties, as well as the identification of biological systems from "Omics" data.

Multi-scale structural mechanics is concerned with numerical algorithms for problems in solid mechanics with materials having complex multi-scale structures as well as complicated time dependent constitutive equations. Using asymptotic homogenization methods, we can compute the effective strenght and durability under fatigue, contact problems with micro-rough surfaces, creep, and impact loading. Currently, woven, non-woven and knitted textile structures built the main application field. For this aim, the FE-based software FiberFEM is developed.

Industrial orders at the start of 2010 were very slow as a result of the financial crisis. In the final analysis, however, 2010 may be called a successful year overall as a result of the subsequent recovery in this sector and the acquisition of substantial research projects.

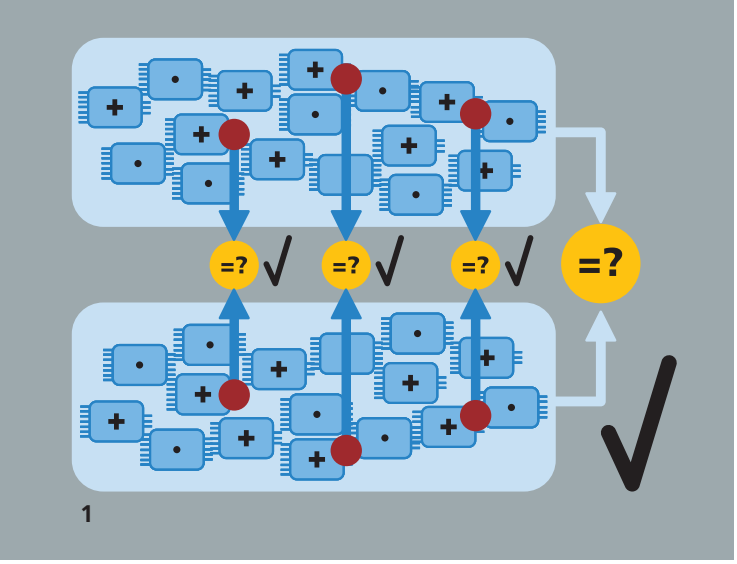
Dr. Andreas Wirsen, Matthias Hauser, Daniel Zoufine Bare Contreras, Dr. Alex Sarishvili, Dr. Christian Salzig, Dr. Julia Orlik, Dr. Alexander Dreyer Dr. Jan Hauth, Alexander Nam, Dr. Anna Shumilina, Richard K. Avuglah, Dr. Patrick Lang, Dr. Hagen Knaf, Annette Krengel, Hans Trinkaus, Dominik Stahl

TOOLBOX FOR MONITORING CRACKS IN POWER PLANT SHAFT LINES

Critical operating states can be initiated in a power plant shaft lines by a number of various structural mechanical conditions, for example, cracks, bearing faults, coupling damage, imbalance as well as interruptions in the electric grid. Thus permanent vibration monitoring is required. Many of these causes, as in the case of the cracks, are recognized by existing monitoring systems as deviations from the normal operating state only when it is too late. The reason is the frequency range analysis processes currently integrated in the existing Condition Monitoring Systems. For example, the amplitude and frequency variations within one shaft revolution characteristic of fracture formation are averaged out in fast Fourier-Transformation.

In the area of signal analysis, algorithms have been developed in the recent past for non-linear and non-stationary vibrations that allow computation of the frequency domain information in each measurement step. This process facilitates the detection of breathing cracks, in particular, in the transient operating state. The improved time resolutions of the frequency domain, however, are not sufficient by themselves to detect the crack because no unambiguous criterion for fracture detection yet exists. It is much more a classification problem for an extensive feature vector to be solved, one that separates the cracks from the other structural effects. A department of E.ON Anlagenservice provides services in the field of vibration monitoring on power plant turbines; Fraunhofer ITWM was approached by them to develop a prototypical software tool for the automatic detection of cracks on the basis of a conceptual analysis of the latest methods from the fields of signal analysis and crack classification.

The time signal from the shaft vibration sensors stored by today's power plant monitoring systems for two different points in time with the same operating state are imported into the toolbox and broken down into single oscillations. Lastly, the frequency domain data is calculated for each sub-signal for every point in time. The classification problem of separating the crack from other structural effects can then be solved using trend data. The analyzed data can be displayed in the form of a frequency spectrum, polar plot, or orbit plot. Relationships between the features can be visualized in radar plots. A follow-on project is planned that will implement a hardware system for the online detection of crack in power plant shaft lines, which is expected to be deployed by E.ON Anlagenservice to power stations.



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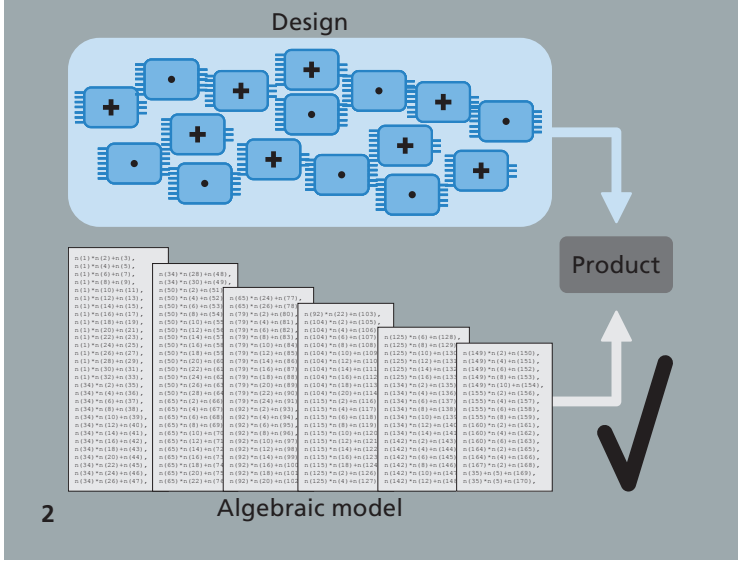


2

INDUSTRIAL ALGEBRA – VERIFICATION OF DIGITAL SYSTEMS

1 Use of topologic similarities in traditional verification

2 Verified Prototyping: Production starts only after a successful verification

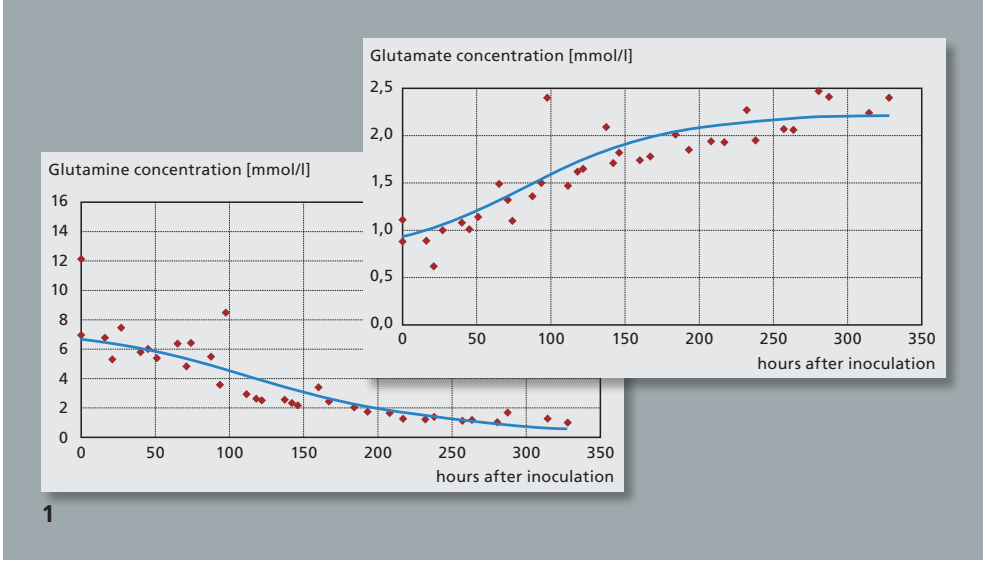
In the development of digital systems, the correct design is indispensible as conceptual errors will inevitably creep from the drawing board into the finished product. The most famous design error has to be the Pentium "bug" from the year 1994. In such cases, besides the expensive recall actions, manufacturers above all must deal with the negative image.

In contrast to an automated process that runs from a given design to the finished chip, the upstream verification is a real challenge. This is where a satisfiability analysis can preclude differences between design and the given specification. However, this is only possible when the two are structurally similar, which is not always the case: For example, in a multiplication process, the result is specified as the product of two numbers, whereas the calculation procedure and, consequently, the internal connections are not.

Modern sophisticated circuit topologies as used are difficult to verify for cost and performance reasons. Nevertheless, because propositional equations can be formulated as polynomials at the bit level as well as many higher-level hierarchies (like multipliers and adders) the algebraic Gröbner Method can be used. A new branch of computer algebra called industrial algebra was founded in cooperation with the TU Kaiserslautern and the mathematics research institute at Oberwolfach, which has already produced two important software developments.

The first of these, the internationally acclaimed PolyBoRi framework for polynomials, was developed using Boolean rings. A sophisticated combination of computer algebra with binary decision diagrams, it makes it possible to process thousand-bit value conditions. The important development here is the interplay of the performing core routines with a kit of expandable algorithms. This was complemented by a specialized approach for such components which can be modeled as polynomials over integer numbers. This is where the software tool GBABL (Gröbner Bases for Arithmetic Bit-Level) was developed, that can quickly verify instruction sets of realistic processors.

GBABL enables verified prototyping, i. e., the verification of small series or single pieces would be too costly otherwise. Similarly, reliability is never sacrificed for systems where security is essential. It is especially critical here that when obsolete devices are replaced with reproductions (retro or legacy computing) the behavior of the new one must match that of the original.



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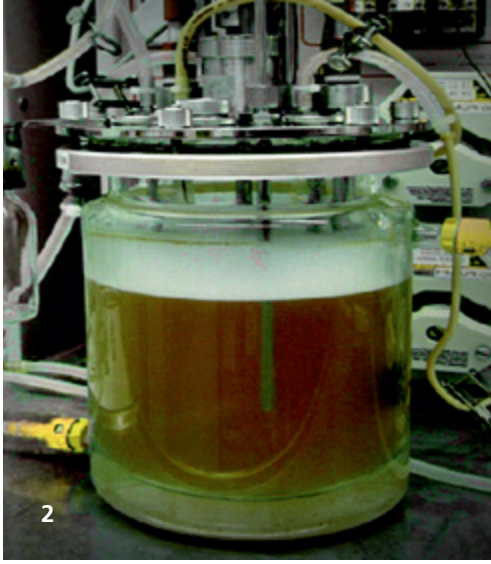
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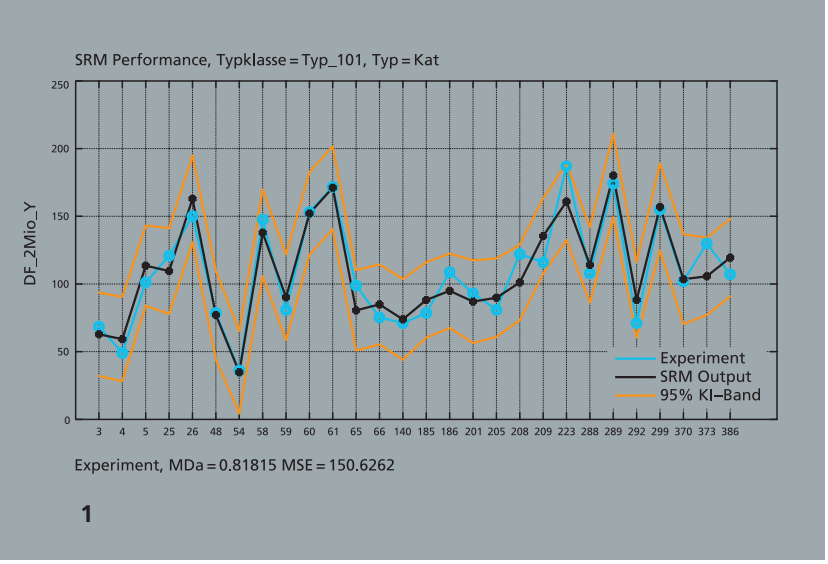
MAVO ZELLPHARM – PRODUCING PHARMACEUTICAL PROTEINS IN ANIMAL CELLS

Immune therapies have an increasingly important role to play in modern medicine. A prime example is the use of antibodies to fight cancer: In the ideal case, the antibodies dock on the cancer cells – and only on these – and mark them so that the body's own immune system detects and destroys the sick cells. Antibodies consist of highly complex protein chains that are not easy to produce with the chemical processes available at present. It requires the aid of living organisms which possess the cell machinery, which alone is capable of assembling the complicated molecules. These cells must have the blueprint for the antibodies they are to reproduce implanted using gene technology. In the past, single-celled organisms like bacteria or yeasts were commonly used, but now the use of animal cells is increasing. Among the animal cells being considered as producers, the one receiving the most attention are the ovarian cells of the Chinese hamster (CHO cells). In contrast to the simple structure of the bacteria or yeasts, the complexity of animal cells is a significant obstacle to their effective use. The success in the development and modification of CHO cells for the production of new antibodies is very random and demands a significant expenditure of time.

Three Fraunhofer-Institutes (IME, FIT, and ITWM) and also the Fraunhofer-Chalmers Centre (FCC) in Göteborg have entered into the joint venture ZellPharm, a three-year, internal Fraunhofer project to accelerate the development of new CHO cells as antibody factories and to improve the production of the antibodies themselves. The combination of system biology modeling with data-driven classification methods is expected to identify so-called biomarkers that will enable predictions in the very early stages of creating new CHO cell lines about the expected yields of antibodies in the future. Poor candidates can be discarded at an early phase and costly further development can then proceed with a much larger number of good cell lines, which significantly raises the chances that a really good producer will be found. The goal of a subsequent sub-project is to improve the actual production phase in a bioreactor through use of a similar model and data-based optimization of the ambient conditions.

1 + 2 *Modeling and simulation of processes in a bioreactor (Data and photo: Fraunhofer IME)*



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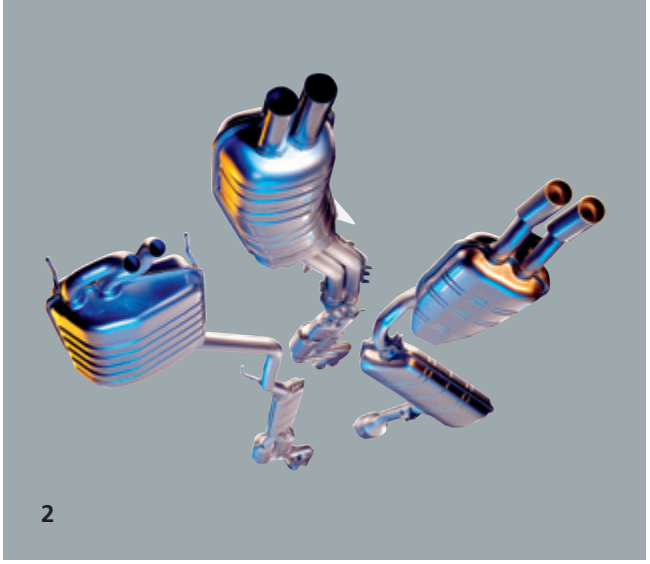

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LIFE CYCLE ASSESSMENT FOR EXHAUST SYSTEMS

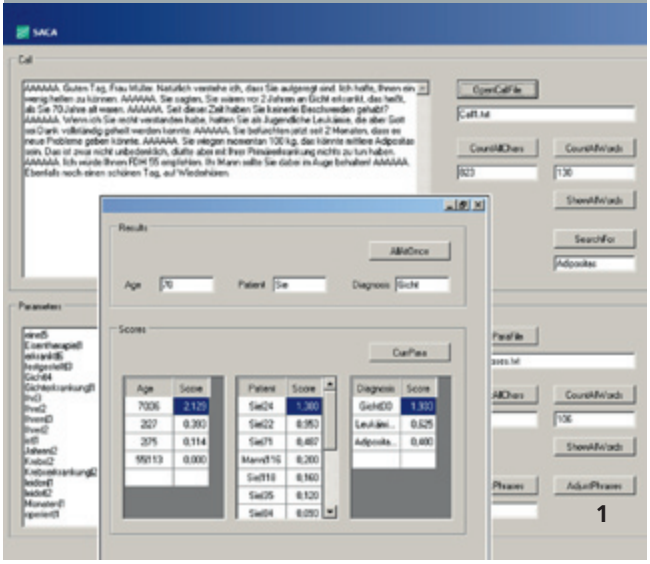
1 Performance of prognosis for fatigue strength values

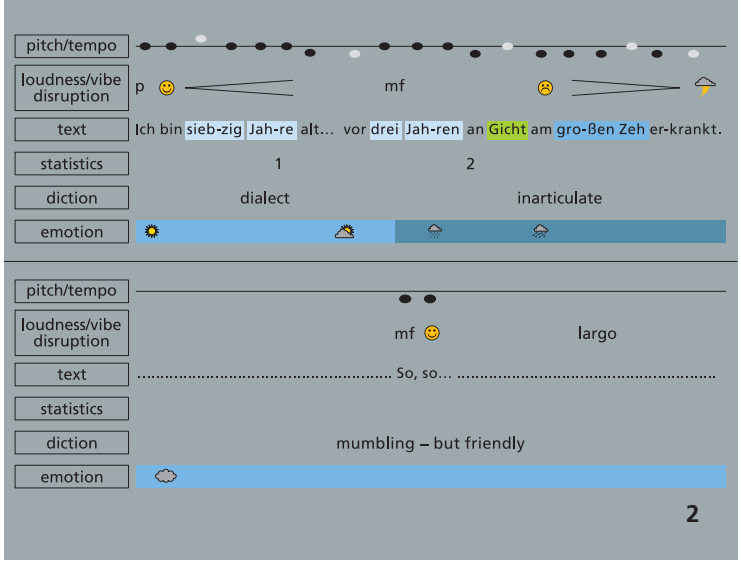
2 Various vehicle exhaust systems (© Eberspächer)

The life cycle assessment for vehicle exhaust systems is primarily interested in the critical fatigue strength values for different load scenarios. The detailed curve of the complete Woehler line values (magnitude of a cyclic stress against the logarithmic scale of cycles to failure) plays only a subordinate role. To estimate the strength, several samples of a structural component are subjected to stress up to the point of failure for two different stress amplitudes. The result provides a statistical distribution of the observed number of cycles up to failure for each of the two stress amplitudes and allows the definition of a certain probability range of survival. Assuming a linear progression of the Woehler lines, by connecting the appropriate points on both horizons, an approximate characteristic curve is defined. The slope of this line represents an important measure in terms of the assessment of the fatigue strength.

To reduce the considerable cost and time effort involved in test performance, the question is asked to what extent previous tests and archived test results may yield a prognosis model which allows estimation of the expected Woehler line values for new components. In addition to the pure prognosis of these values, there is also a particularly strong interest in the inferable information about the significance of the various influencing variables that can be gained from the identified model. Namely, engineers can obtain important information to improve the fatigue strength early in the design and development phase.

This project implements mathematical algorithms for reducing the dimensions of the data range, for selecting a model from the class of linear models, and a special class of neuronal network for knowledge extraction from the models and for the Design of Experiments (DOE). The two major requirements were the opportunity to transfer knowledge from the experts to the modeling mechanisms of the software and the chance to interpret the results obtained from the model. In order to satisfy these requirements, an expert-based pre-selection of the significant influence variables is needed. This step leads to a sharp reduction in the number of possible models and enables a subsequent, complete search for a model within a reduced model range. The implementation of DOE provides the user the opportunity to improve an existing, statistically significant model with the optimal experiments. The implemented method is currently being thoroughly tested with the main focus being on enlarging the available data base and on pre-grouping the extremely varied range of exhaust systems.





SOFTWARE BASED ANALYSIS OF TELEPHONIC MEDICAL CONSULTATION SERVICES

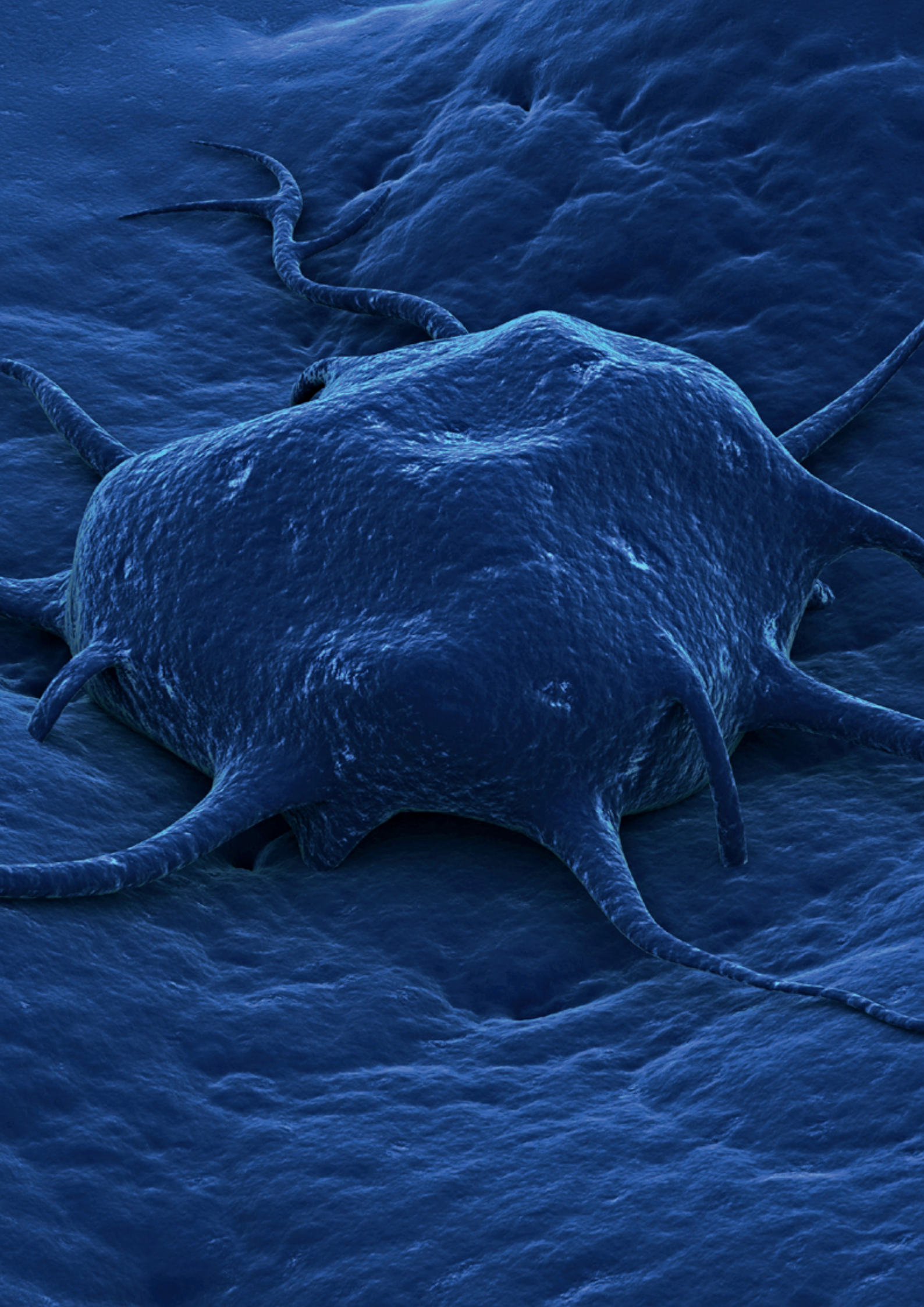
How can 30,000 telephone consultations every year be interactively analyzed, evaluated, and improved? This is the question asked by the Cancer Information Services of the German Cancer Research Center (Deutsches Krebsforschungszentrum, DKFZ) in Heidelberg and the Federal Ministry of Health has funded a project to study the answer. A new and innovative concept was developed that is based on structures similar to a musical score. By means of a duet, conducted by the consultant, the core content of the conversation can be automatically extracted. This is achieved by means of voice recognition software components which track and support the known portion of the conversation provided by the advising partner. Keyword spotting technology is used for the unidentified caller's portion of the consult in order to identify specific values (key terminology contained in the quantity of expected values provided). The extracts from both of these parts of the consultation are mapped on an abstract structure through specially developed software and then stored with respect for the provisions of the data protection laws. The resulting data archive serves as the basis for an interactive, graphically supported exploration of separate dialogs, or dialog clusters, and opens a whole new approach for improving consultation results.

Data collection in the project is initially limited to unstructured text provided by a time delayed transfer of the recorded (trained) consultant-side of the telephone dialog, which is then subject to a special heuristic analysis. Overall, the experiments performed for the automatic extraction of subject-relevant key word content were positively executed and demonstrate the feasibility of the complete project, which includes several more advanced aspects: for example, immediate online support during the consultation (e. g., perhaps through an adaptive source selection from the KID information pool) as well as the automatic detection and identification of emotional responses to special events and constellations.

Several of the findings were presented under the title SACA – Software Assisted Call Analysis – at the ICCH 2009 (International Conference on Communication in Healthcare) in Miami and at the EACH 2010 (European Association for Communication in Healthcare) in Verona. The exhibits were very well received by representatives of the nursing care occupations and the medical profession.

1 *Screenshot of a simple SACA test*

2 *Prototype of a "Duet"*



OPTIMIZATION

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

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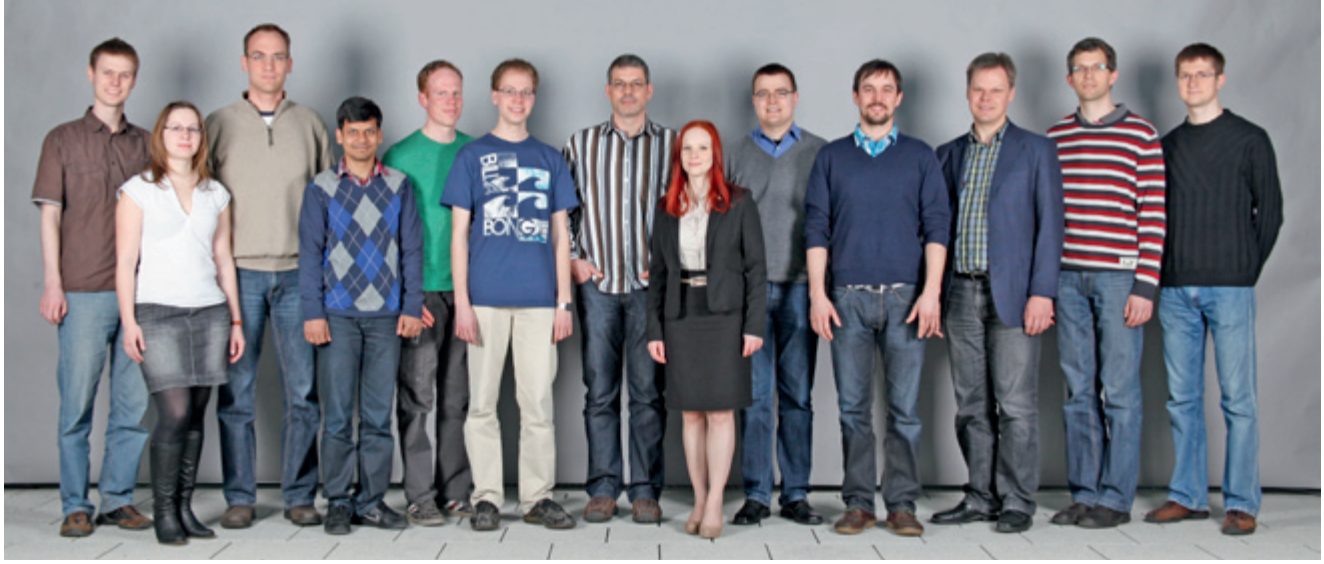


The department develops custom solutions for planning and decision making problems in logistics, engineering, and life sciences. In close cooperation with research and industry, the core competence of the department is the development and the implementation of application and customer-specific optimization methods for calculating best possible design solutions for processes and products. The close integration of simulation and optimization algorithms that take multiple criteria approaches into account is characteristic for the department which also develops and implements interactive decision support tools. Overall, optimization is viewed not so much as a mathematical problem to be solved, but rather as a continuous process that develops suitable tools to support the customers goals.

The optimization of business structures and processes involves consulting and support in modeling logistical concepts as well as developing individual software components. Some of the main activities are: the development of efficient strategies for transportation logistics, layout and load balancing for production processes, models and algorithms for planning and disposition of process activities in hospitals such as patient transport and OR-Scheduling, and mathematical modeling of strategic and operative planning tasks in public transportation systems. In interactive therapy planning, we develop new methods for planning clinical radiation therapy on the basis of multiple criteria optimization. The research study group is developing, in association with Massachusetts General Hospital, German Cancer Research Center, Fraunhofer MEVIS, and Siemens Oncology Care Systems, an innovative optimization and evaluation tool that facilitates decision making related to the trade-off between opportunity and risk for radiation therapy planning by medical physicists and physicians. The use of mathematical optimization methods in the engineering disciplines relies on physical modeling of the technical processes and on mapping them into computer programs (Virtual Engineering). Current projects are involved in the areas of electronic design, gem cutting, design of chemical processes, layout of adsorption coolers, and the optimization of rolling processes in steel production. Optimized products and process layouts are shown to decision makers for evaluation and selection by use of interaction decision support tools.

Despite the hesitant start, the year 2010 was characterized by successful business. Some of the special highlights include: the R&D activities with the Paul Wild Company to prepare a product (software and hardware) for a fully automated colored gemstone production line, the start of a project for the multi-criteria optimization of chemical processes at BASF SE, the order from Ante-Holz Company to build a software suite for the optimization of timber products, and the start of a strategic partnership with SIEDA Company for hospital personnel planning. Furthermore, the joint venture with proAlpha Company involving production planning optimization is continuing as is the work on truck chassis design with Volvo 3P (Göteborg). Besides having four completed PhD theses, other academic news includes: approval of the Software Cluster of Excellence Südwest to pursue the optimization of business structures and processes, and a market-oriented run-up research project to optimize focused ultrasound therapy in the focus area "Medical Treatment Planning."

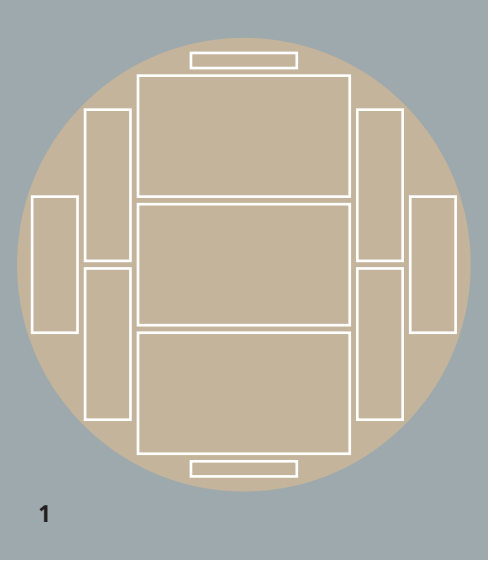
Dr. Volker Maag, Christina Erben, Hendrik Ewe, Chitiz Buchasia, Dr. Michael Bortz, Bastian Bludau, Dr. Peter Klein, Jasmin Kirchner, Richard Welke, Dr. Martin Berger, Dr. Michael Schröder, Dr. Heiner Ackermann, Dimitri Nowak
Dr. Alexander Scherrer, Jorge Ivan Serna Hernandez, Katrin Teichert, Dr. Ingmar Schüle, Neele Hansen, Kai Plociennik, Prof. Dr. Karl-Heinz Küfer, Uwe Nowak, Tabea Grebe, Dr. Agnes Dittel, Dr. Martin Pieper, Dr. Sebastian Velten, Dr. Philipp Süss, Andreas Dinges, Jan Schwientek

RIDE-SHARING FOR ROAD FREIGHT

Within the German transportation sector, many operating companies can not charge their truck fleet to capacity, or let their trucks travel long distances empty. The companies concerned therefore acquire more orders than they can handle with their own fleet, and select those which can be combined to good tours. The remaining ones are then subcontracted. This approach is unsatisfactory in many respects. First, subcontractors are relatively expensive, and secondly, the order backlog is often still too small to be able to plan substantially better tours for the entire fleet of trucks.

The decisive way to further increase the job pool is to take part in cross-company cooperation. Thereby associated companies cooperate, and provide those jobs they would normally pass on to subcontractors to a common order pool established by the collaborative community. Interested carriers can use this order pool to supplement their existing tours, so that the fleet utilisation increases. The resulting profit is divided by a set of rules between the partners.

The department Optimization developed within the past two years a prototype platform providing a common order pool to freight carriers. The development was funded by the "Stiftung Rheinland-Pfalz für Innovation". The software implementation was preceded by a prolonged period of game theoretic modeling and analysis, as the rules for take-off orders and calculating the subsequent transfers of funds should take into account the individual interests of participants. On one hand, incentives to participate need to be established, on the other hand, the rules should ensure a certain degree of fairness: no one should be able to enrich themselves under the collaboration at the expense of others. Another major problem which must be solved on the way to the practical use of such a platform is the integration into existing planning processes. Ideally, participation does not fundamentally alter existing processes, but merely adds to them. The proposed platform is therefore designed as a complementary tool to existing planning processes. In a pilot study with data from a large German freight carrier it has been shown that substantial savings can be generated with the help of the platform.



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2

OPTIMAL SOLUTIONS FOR CUTTING PROBLEMS

1 *Sectional view with maximum yield*

2 *Wooden boards of different dimensions*

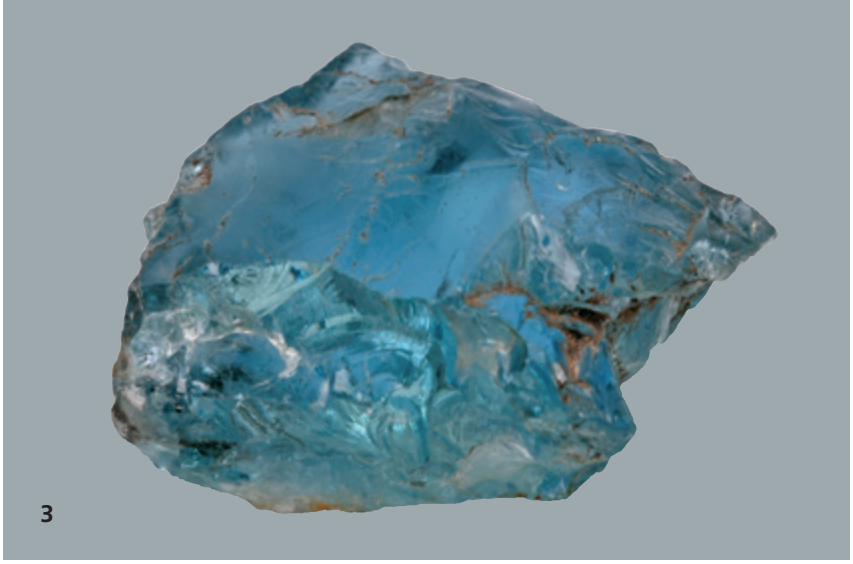
An integral part of many production processes is the cutting of blanks into products. In the wood processing industry, for example, logs and shelves are sawn, in the metalworking industry different components are stamped out of metal plates, and in a variety of industries coils of different materials are tailored. For all these jobs, quite different cutting tools are used, such as circular and band saws, water and laser beams or die-plates. In many applications, however, the blank cannot be completely converted into products, but useless waste is created that ought to be minimized. The department is currently working on several such cutting problems and develops innovative solution methods for various applications. It considers not only the actual cutting problem, but also analyzes it holistically, embedded in the respective production process.

These approaches go far beyond traditional methods for/of modeling and solving cutting and packing problems, which can be divided roughly into three categories:

- From a given selection of products, place as many as possible in a blank of fixed dimension.
- Place a selection of products in a blank of minimal size. The size and shape of the blank are, subject to certain restrictions, variable.
- Place a selection of products in a minimum number of blanks of fixed dimension.

Typically, the products and blanks for these tasks are simple geometric objects such as circles or rectangles, or can be approximated by such. Also the permitted designs are often subject to strong restrictions. For example, one often requires that the designs form a guillotine pattern. Such an arrangement can be achieved by a sequence of straight end-to-end sections, so-called guillotine cuts. The exploration of such problems has a long tradition in mathematics, which accordingly led to the development of a variety of exact and approximate solution methods. Due to the size of many practical problems one can often only apply randomized search procedures and metaheuristics.

A typical example for practical cutting problems considered in the optimization department is the problem of minimizing waste in sawmills, where boards of different grades and different dimensions are cut from logs. The cutting process is relatively complex and involves a large number of conditions that must be considered in the placement of the boards within the log. To minimize waste one has to decide which boards to place within which region of the log. In addition to that, one has to care about a variety of further information such as different quality levels, stock information and sales forecasts. Furthermore, it is necessary to consider the waste minimization problem in the context of the whole production process. A waste-optimal cutting pattern can often only be achieved with considerable additional expense. Hence, whenever



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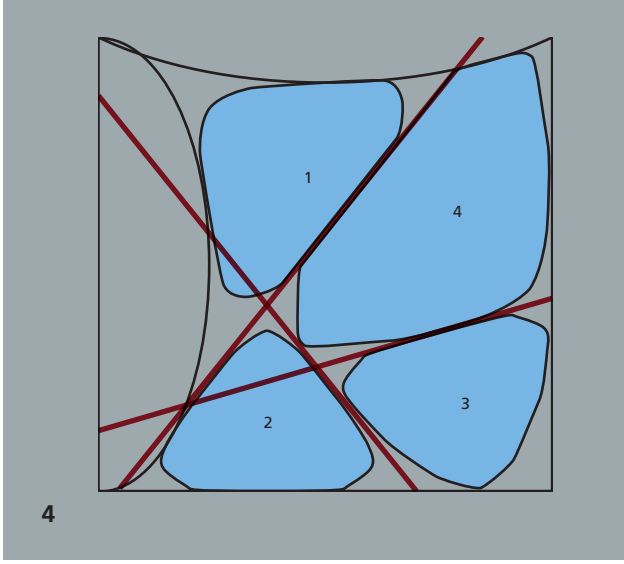

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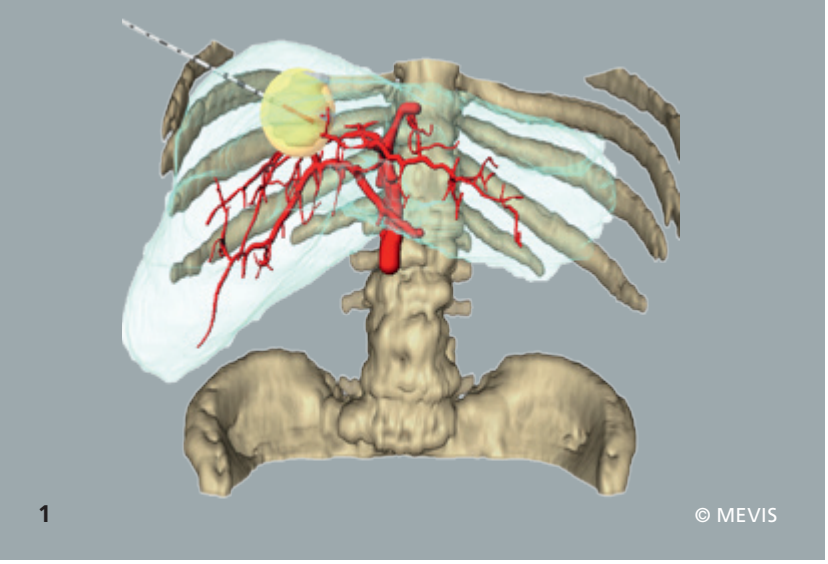
appropriate, it makes sense to allow for a little more waste, but at the same time reduce production time and costs and thereby increase efficiency. This requires not only modeling the actual cutting problem, but also modeling of the complete production process and thus leads directly to a variety of competing objectives, which have to be solved in a multi-criteria optimization problem.

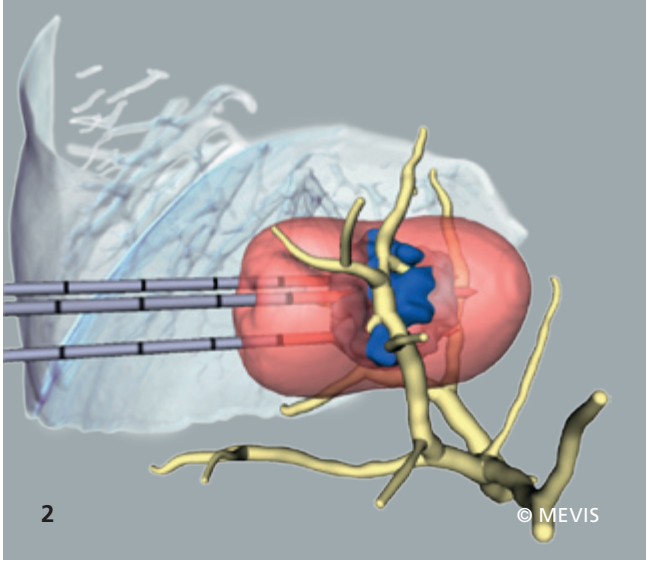
Another example of a cutting problem considered in the optimization department is the computation of decompositions of a raw gemstone in blanks that maximize the yield of the resulting jewels. For this purpose it is necessary to avoid inclusions as far as possible, or to place them at inconspicuous places in the final products. In contrast to the classical cutting problems, gemstones have irregular shape and the jewels are described parametrically and by restrictions on the size and shape. For example, it is required that the ratio of width and height of a gemstone must be within a predetermined interval. This directly requires to model aesthetic issues, since they have a significant influence on the value of the jewels. While minimizing waste the number of jewels and their geometries are calculated on the basis of aesthetic aspects. These issues can successfully be modeled and solved as general semi-infinite optimization problem. The department is strongly involved in both advancing the theoretical boundaries and the practicable implementation of the process.

In the context of these and other projects, the optimization department gathered expertise in modeling and solving cutting problems. While each question requires an individual approach, synergies can always be found. In some of the practical cases, and especially for gemstone cutting, the developed approaches lead to a revision or even reformulation of the production processes.

3 *A raw gem to be cut*

4 *Volume maximal guillotine pattern of four gem design in a two-dimensional container*





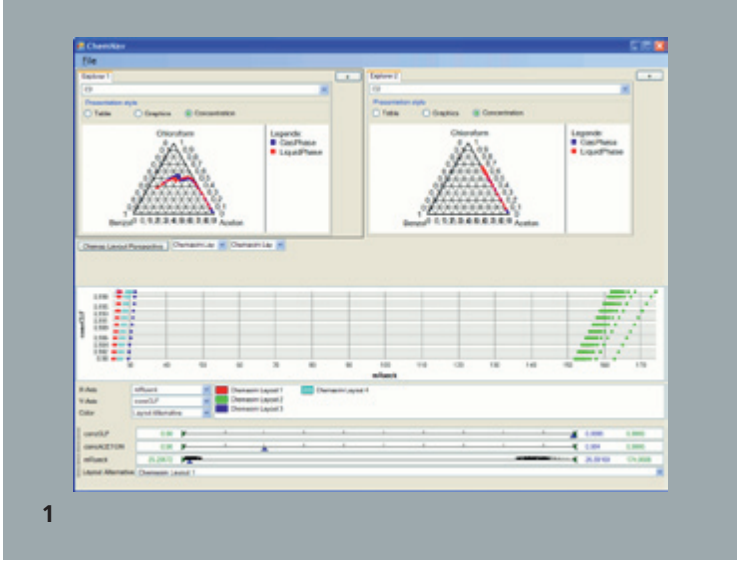
OPTIMIZATION OF RADIOFREQUENCY ABLATION OF LIVER TUMOURS

1 *The tumour (shown in grey) is not completely enclosed by the critical isothermal line (in yellow) with this applicator position – the upper corner is too cold. This visualization also shows that the applicator neither pierces any ribs nor large vessels.*

2 *The critical isothermal line (shown in red) to destroy the tumour is deformed by the cooling effect of large vessels (in yellow). Consequently, the tumour (in blue) is not completely destroyed by this applicator positioning.*

Radiofrequency ablation (RFA) has emerged in recent years as a minimally invasive alternative. A needle-shaped applicator is placed from the exterior through the skin inside the tumour with the aid of medical imaging systems like ultrasound or X-ray computed tomography (CT). High-frequency alternating current is passed into the tissue via the applicator. As a consequence, the tissue heats up and is destroyed. It is highly important to completely destroy the tumour in RFA because surviving cells may develop resistance towards heat and promote more aggressive tumour growth. In order to provide more assurance for doctors, the "Medical Therapy Planning" (MTP) group and colleagues at the Fraunhofer Institute for Medical Image Computing MEVIS currently develop an imaging-based planning system for patient-individual planning of RFA therapy. The goal is to minimize the risks particular to every patient and improve the quality of the therapy. The decision support software that is being developed will be used for therapy planning in clinics and other treatment sites as well as for training purposes for becoming doctors.

A tight coupling of optimization routines developed at the ITWM and a simulation model for predicting the heat distribution in the patient body by MEVIS serves as the mathematical core of the system. Based on the software MeVisLab, the system allows the doctor to calculate the heat distribution in the tumour and surrounding tissue for any given applicator position. This enables systematic planning of important clinical aspects of the therapy. The complete ablation (removal) of the tumour, for example, can be guaranteed by restricting the applicator positions to those for which a complete destruction of all malignant tissue is predicted by the simulation. Additionally, the software incorporates into the planning process critical anatomical structures that obstruct the passage to the tumour (such as the ribs) or that may not be damaged by heat. Mathematically, there is a surprising similarity to the project of "optimal utilization of coloured gemstones" of the group "optimization in Virtual Engineering". The goal there is to fit a given form into a raw gemstone such that it is maximal in volume but still enclosed in the raw stone. Here, in contrast, the aim is to fit the tumour volume in a small but enclosing isothermal. To this end, existing optimization problems and solution methods have been reformulated and extended. Thus, the competency of the department in the field of "semi-infinite optimization" finds its application in medical therapy planning. With the help of this competency and more mathematical techniques for multi-criteria optimization and for the simulation of heat in the background, and with an intuitive user interface, the planning system allows finding the best compromise between the conflicting goals of RFA for each patient. As in other projects of the MTP, tools and techniques are created here to maximize chances of healing of a therapy while at the same time minimizing the risks of side effects.



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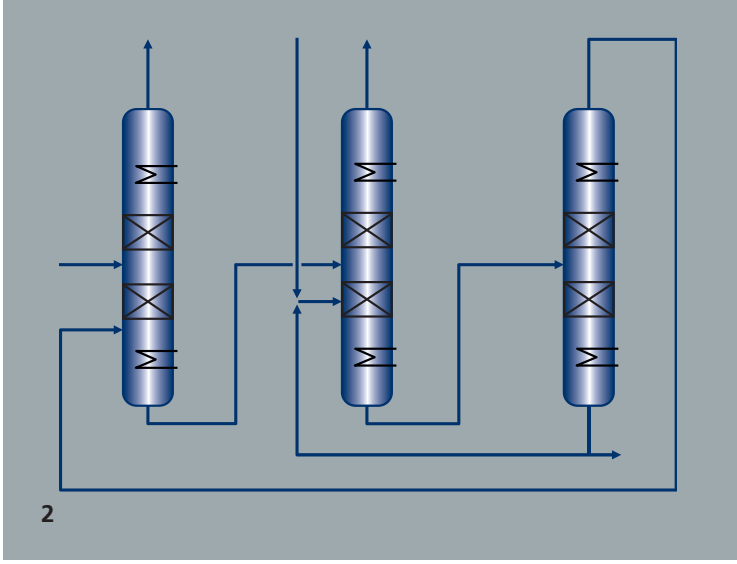

2

MULTICRITERIA DECISION SUPPORT IN PROCESS DEVELOPMENT IN CHEMICAL INDUSTRY

Production of chemicals requires high purity of the final products at minimal operating and investment costs while at the same time, health-, safety- and environmental issues have to be taken into account. In a project with the BASF SE, this multi-objective optimization problem in process development of chemical production plants is investigated and pareto optimal solutions should be provided to the user. These solutions have the property that an improvement in one objective can only be achieved by getting worse in at least one other objective. One typical example is the purification of bioethanol in a distillation plant. The goal to achieve a maximal purity of bioethanol is in opposition to the raw material costs, the energy costs for operating the plant and to safety and environmental requirements. Process engineers at the BASF SE use a highly performing software which is able to describe chemical plants in detailed simulations with good agreement. Generally however, it is not clear in how far the choice of parameters in those simulations offers further potential such that, e. g. the same or even higher purity of the final product can be achieved at lower operating or even lower investment costs. The software to be developed by ITWM is supposed to yield answers to these questions and to find these pareto-optimal solutions. In this project, chemical processes are considered which involve distillation columns, reactors, decanters and mixers. In these devices, the different physical and chemical properties of the substances are used for their synthesis and separation. Connected to each single device are feed and product streams, whose quantities and compositions can be adjusted within the constraints set by the physical and chemical properties. In general, for the separation the combination of several devices is necessary. Thus determining the optimal process parameters for a complete process configuration is a challenging task to both the model and the algorithmic implementation of the simulation. With respect to an efficient simulation it is important to obtain a fast overview of the parameter space and to identify the allowed regions within this space. Since the complete simulation with the BASF-owned software for the entire parameter space is too time-consuming, such an overview is based on a simplified model which describes the physical reality within certain approximations. This is the first of three aspects which make up the project.

Once interesting parameter regimes are identified within the simplified model, the BASF-owned complete simulation is combined with optimization routines to find solutions in these regimes which are optimal according to criteria specified by the user. This combination of the simplified model with the complete simulation forms the second aspect of the project. The users are then given the possibility to navigate the solutions in an adequate graphical user interface in order to arrive at a well-founded decision. This decision made by the user then is optimal in the sense that no improvement in any objective can be obtained without worsening another objective. The development of the graphical user interface is the third aspect of the project.

1 *Prototype of a user interface for visualization and navigation of optimal solutions*

2 *Example of combining three distillation columns with two feed and three product streams*

FINANCIAL MATHEMATICS

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

Head of Department
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The department of Financial Mathematics works in all areas of modern financial mathematics. Clients are national and special banks, insurance companies and pension funds, asset management companies, and consulting firms specialising in banking and insurance.

In the area of Option Pricing we develop and implement numerical algorithms for the efficient and accurate valuation of all kinds of options in modern equity, interest rate, and commodity models like e. g. the Heston and Cheyette model. Here, cross hedging constitutes a new area of research explored in 2010. In Portfolio Optimization we investigate conventional static approaches like Markowitz and Black-Litterman as well as innovative modern methods. In the fields of Worst Case Optimization and Optimal Portfolios for Managers the department is an international leader. In the area of Credit Risk we support, from the statistical point of view, credit institutions in complying with the new Basel II standards. After earlier successful collaboration in the development, calibration, and validation of ratings, we meanwhile support our customers also in back and stress testing. Credit Derivatives, being one of the responsible catalysts of the financial crisis, pose a particular challenge in their valuation. In this domain, market and research are still developing further which results in high demand for mathematical modelling and support. In Insurance Mathematics our main focus lies on working with and on the software tool ALMSim. This tool supports insurance companies in implementing Solvency II and permits the individual modelling of assets and liabilities as well as their coupling. In the area of Interest Rate Modelling we develop generic valuation algorithms allowing for a large diversity of complex interest rate derivatives.

In 2010 a large part of our income from industry was in the area of interest rate derivatives (see project overview Interest Rate Derivatives). This topic also dominated the series of workshops held for industry partners as well as in Kaiserslautern and London. A new partner – teckpro AG in Kaiserslautern – could be acquired working in retirement planning. Moreover, together with Lotto Rheinland-Pfalz and Hessen we concluded a project which above all dealt with complex combinatorial problems (see project overview Bingo). The new EUROSTARS project NORM was initiated at the end of the year. In this project we investigate methods for automated risk valuation based on semantic analysis of news feeds. The BMBF project Alternative Investments was successfully completed. Altogether, the aftermath of the financial crisis lead to an average economic result for the department.

The collaboration with the University of Cambridge was further deepened. Interesting scientific results could be obtained in common research projects on statistics of Lévy processes and portfolio optimisation. Furthermore, together with OptiRisk Systems and the University of Cambridge, the already mentioned series of workshops in the area of »Modern Financial Mathematics for Practitioners« was established. This intensifies our efforts to be present on the London Financial Market.

Finally the Department became a strategic partner of the newly founded European Institute for Quality Management of Financial Algorithms and Products (EI-QfM). In 2011 we expect to take part in the certification of products and providers in the financial and insurance sector.

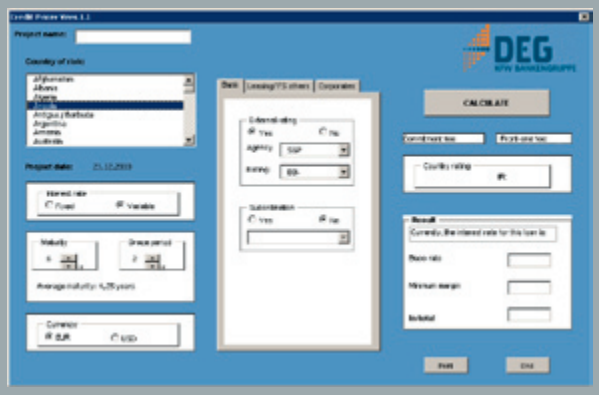
Tilman Sayer, Dr. Christina Erlwein, Andreas Wagner, Prof. Dr. Ralf Korn, Yulia Mordashova, Dr. Peter Ruckdeschel, Nataliya Horbenko, Dr. Sascha Desmettre, Dr. Gerald Kroisandt, Dr. Johannes Leitner, Dr. Jörg Wenzel, Roman Horsky, Nora Imkeller, Dr. Johannes de Kock

PRICING OF INTEREST RATE DERIVATIVES

In order to optimally invest insurance premiums, insurance companies usually buy securities at the capital market. To do so, these companies emit securities by providing a certain amount of money to some debtor, obtaining in return interest rate payments which are usually fixed. For some types of securities however the payments are not fixed but are linked to certain reference rates which are more or less volatile. An example for such a structure is a so-called CMS-Steepener, which gives the debtor the obligation to pay the difference between the current 10-year and the current 2-year rate as long as this value is positive (floor) and does not exceed a certain amount (cap). Furthermore, additional rights can be granted to the debtor, such as call rights, put rights (buying another security under predefined conditions) or conversion rights. Securities, constructed in a similar way are called structured interest rate products. There are many such products with completely different features. The market value of these products depends in particular on the development or the variance of the interest rate curve. Therefore, for the valuation of such a product it is crucial to be able to model the evolution of the interest rate as accurately as possible. So called one factor models are widely in use. This approach models the uncertainty of the capital market using one risk factor. These models, however, are not very flexible meaning that they are hardly able to cover all possible market scenarios by adjusting the input parameters. Especially the results of the recent financial crisis such as low short-term interest rates cannot be modelled in a sufficient way.

The financial mathematics department, in cooperation with the risk control department of the German insurance company R+V Versicherung AG, evaluated the R+V valuation software for the portfolio of structured interest rate products. While converting the software to a new programming language the valuation algorithms were refined. The previously used algorithms are sufficient for the requirements of R+V. By introducing a new innovative two factor model developed by our department, R+V is now moreover able to cover a greater variety of market situations. Using optimized calibration algorithms, the model parameters can now be chosen in such a way that the model reflects the actual market situation. This gives R+V a competitive edge in difficult market situations. Moreover the improved software can easily be extended by new products, allowing adapting quickly to new market situations.

Another responsibility of risk controlling is the valuation with different varied interest rate curves and thus getting an overview of several risk exposures. Also structured products are decomposed into their simple components such as embedded options. These requirements are covered in the project so that official government and statutory regulations with respect to the valuation of structured products are still more than satisfied.



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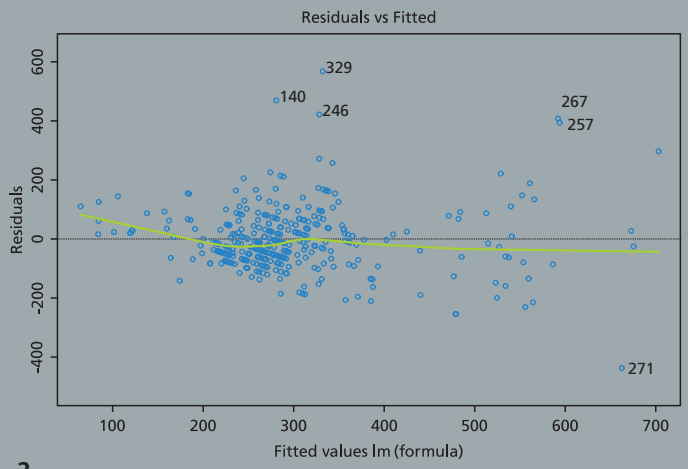


2

LOAN PRICING IN ILLIQUID MARKETS

1 *Graphical User Interface of the loan pricing tool*

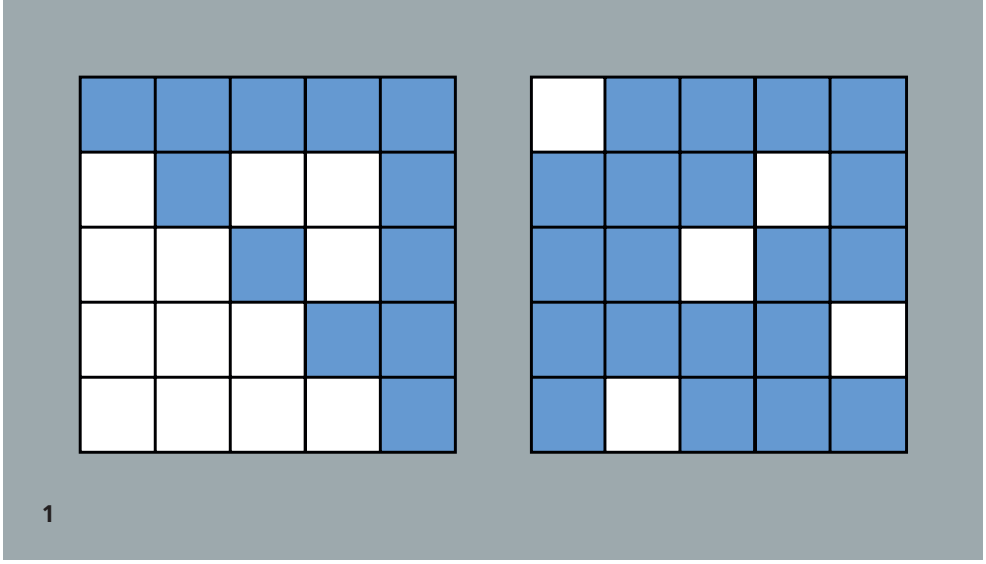
2 *Example for model diagnostics: residual plot*

Loan pricing for developing and emerging markets is more challenging than pricing in liquid markets, since data sets from these markets and countries are often scarce and incomplete. In a project with Deutschen Investitions- und Entwicklungsgesellschaft mbh in Cologne (DEG) we developed a pricing tool, which allows calculation of daily loan prices and margins for banks, financial institutions and corporate clients in about 180 countries which are in line with current markets. To this end, we extract default spreads from market observations and attribute them to individual pricing determinants. The developed pricing tool asks the user to enter information about the loan (e. g. currency, maturity, rating and subordination), and then returns the actual loan price for the given parameters based on current market data.

For lack of data for developing and emerging markets, data from various sources has to be merged for modelling. In close cooperation with DEG we could set up a suitable data base covering, on a daily basis, country- and sector-specific default risks, e. g. by credit default swap spreads, emerging market bond index spreads and ratings from several rating agencies. In addition, we use a data base covering detailed information on individual issues and loans for pricing further loan characteristics. Data sources are joined by date, maturity, country and sector information, applying suitable smoothing, interpolation and grouping techniques.

By means of a suitable regression model, a loan price can then be determined by means of this data base. Our criteria for model selection are adjusted r^2 as well as cross validation to avoid over-fitting. Due to the heterogeneous data sources and varying data quality, careful modelling has to be aware of outliers and to avoid attributing overly high influence to single observations. This may be achieved by robust regression procedures. Lower bounds for loan prices – also of interest for DEG – may be obtained by quantile regression. Our tool provides several such (classical, robust, quantile-) regression fits for internal discussion within DEG while the graphical user interface of our tool only issues one of these according to internal decisions at DEG.

Finally we developed a validation concept which provides procedures when the data set used for model fitting is changed. On the one hand we have a time-scheduled revision scheme, on the other hand, we permanently control the quality of the model fit, summarized in a traffic lights concept.



1

A NEW DESIGN FOR THE BINGO LOTTERY

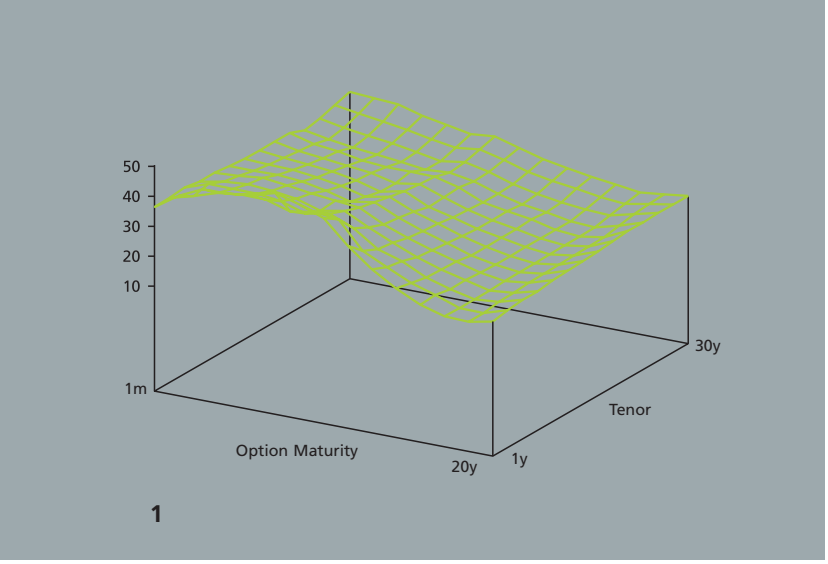
1 *Highest winning category and no bingos (blue: fields with selected numbers)*

The main challenge for this project, which is only partially concerned with financial calculations, is to create a program that designs the new bingo lotteries for the German states of Hessen and Rhineland-Palatinate. In the traditional game of bingo, the players sit together in the "bingo hall" and hold playing cards with pre-printed numbers. The caller draws numbered balls at random from a basket and calls out the number to the players. When the number drawn is a match with one of the numbers on a playing card, the player marks this field. Numbers are drawn until the first player to get a bingo (a vertical, horizontal, or diagonal straight line pattern) announces that they are the winner by shouting out to the caller "Bingo!" The game is over when the winning card pattern is confirmed.

The difference in a state run lottery is that there are too many players to all sit together, so the drawing is modified by defining a fixed number of balls for the drawing. In this way, so many numbers are drawn that a player may be able to mark more than one complete line. The various categories of winners depend on the number of completed vertical, horizontal, or diagonal lines confirmed as winning bingo patterns. The highest category consists of three or more marked vertical, horizontal, or diagonal lines. The standard bingo card is arranged in a five by five grid of rows and columns. The horizontal rows always contain a certain range of numbers, e. g., the first row from 1 to 15, the second 16 to 30, etc., until the last row where the numbers range from 61 to 75. What makes calculating the probabilities of winning so difficult for each of the various categories is that not only the number of marked fields, as in traditional bingo, but also the pattern must be considered. The illustration shows that it takes only twelve numbers to win the highest category (three winning patterns). However, it is also possible to select twenty numbers and not win at all.

In the early days of the game, there was no standard game design (number of rows and columns, range of numbers for each row, number of selected balls, winning patterns, free spaces, winning categories, etc.). The challenge was to discover and implement a fast algorithm to analyze all the winning probabilities for the various configurations. The algorithm we have implemented needs less than one second to determine the winning probabilities of the current configuration.

Besides this program for testing the various configurations in the run-up to the launch of Bingo, we have also created the program for generating the playing cards and the program for evaluating and calculating the payout amounts.



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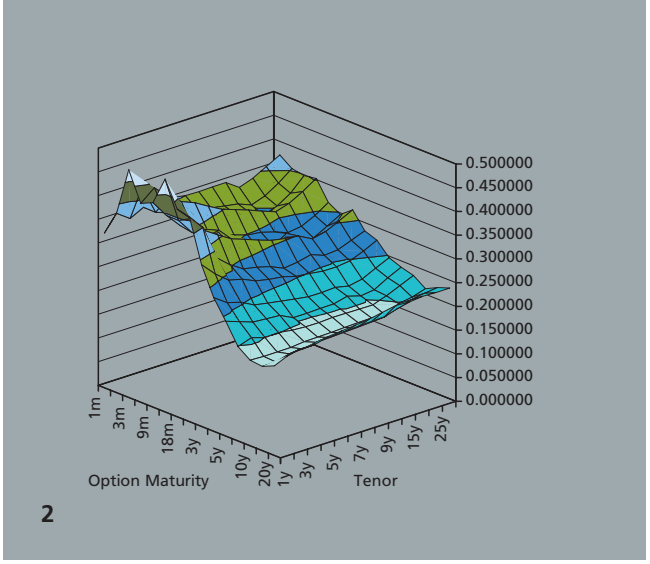


2

CALIBRATING AND COMPLETING THE VOLATILITY CUBE

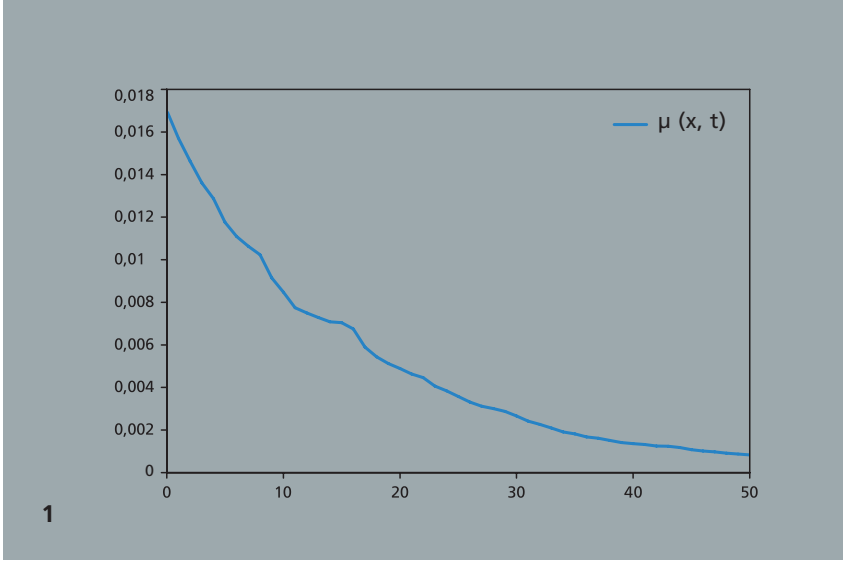
1 *Volatility surface (ATM)*

2 *Volatility surface (Strike = 25 bps)*

Swaptions (options on interest rate swaps) are characterized by three parameters. These include the option maturity, the swap length or "tenor" and the strike. An implied volatility can be inferred from the market data for each swaption. It is common practice to construct a cube (the "volatility cube") containing these volatilites. The above-mentioned parameters form the three dimensions of this cube.

Each cut (or plane) of the cube is known as a volatility surface. The complete volatility surface representing the ATM (at-the-money) strike is part of the market data. Frequently traders only obtain incomplete volatility surfaces from data providers for strikes different from the ATM strike. An example of such a strike is a strike which is 50 basis points to the left or to the right of the ATM strike.

As part of a small project with Assenagon GmbH from Munich, the SABR model had to be calibrated to given market data and the volatility cube had to be completed. The market data in this case contains only a small number of volatilities. Therefore, the cube is only sparsely populated in its initial state. The ATM volatility surface is complete, but only some volatilities are known for the remaining strikes. The SABR model has to be calibrated per option maturity and swap length. This means that for many a pair (consisting of an option maturity and a swap length) only one volatility (ATM) is present in the market data. Interpolation would not make much sense due to the highly non-linear structure of the volatility surface. Thus, option maturity-swap length pairs for which few volatility values are known are also calibrated instead of being interpolated. The values of the (already) calibrated neighbouring pairs are used as the starting values in these calibrations. Furthermore, the calibration makes a flexible trade-off between the quality of the calibration and the smoothness of the volatility surfaces.



1

HEALTHY AGEING WITH MATHEMATICS – MATHEMATICAL MODELS FOR LONGEVITY

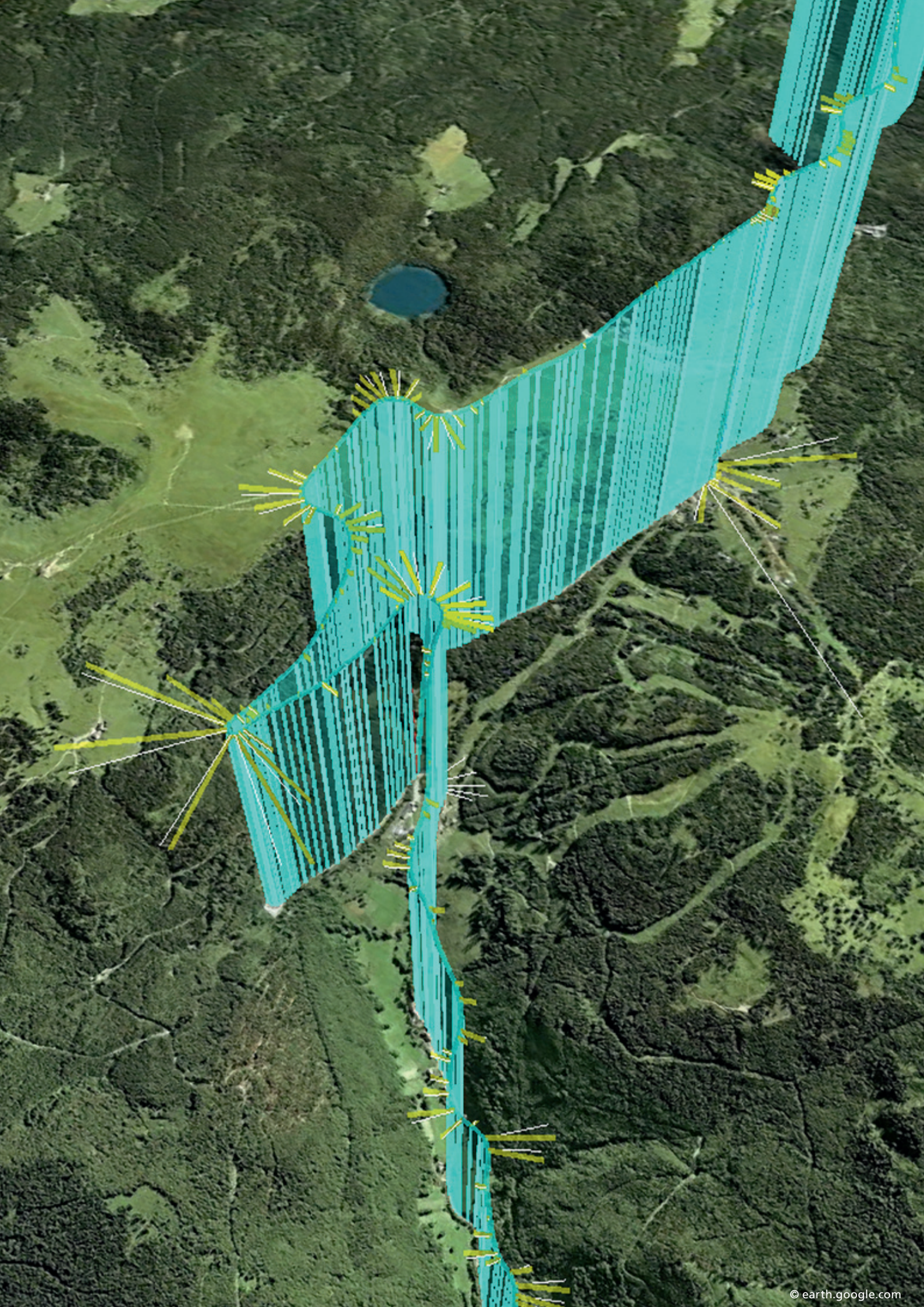
A long and healthy living is a desirable goal for each individual. However, the life insurance industry has come up with the somewhat irritating term of longevity risk to denote the unexpected and seemingly random increase in the life time of the population during recent decades. Indeed, a reliable prediction of the evolution over time of the duration of the life of the population is a real challenge. This is particularly important as the longevity risk cannot be hedged at financial markets in the same way as the interest rate or equity risk. And this remains true despite the appearance of the first mortality or longevity bonds (such as the mortality bond issued by Swiss Re in 2003 or the longevity bond offered by EIB/BNP in December 2004) or of mortality swaps.

Besides continuously updating life tables and introducing generation life tables, the development of so-called dynamic mortality models is an alternative based on mathematical modelling that is particularly suitable when used to value finance or insurance products related to the lifetime of the insured. Dynamic mortality models are generalizations of classical mortality models (i. e. models where the age dependent mortality intensity is modeled in a paramteric way (but independent of the calendar time)) where it is assumed that the determining parameters evolve over time according to the dynamics of an underlying stochastic process.

A simple example that admits an excellent fit for German data is the stochastic Gompertz model that has been developed at Fraunhofer ITWM during an industry project and as part of a PhD thesis. In this model, it is assumed that the general mortality decreases (nearly) deterministically as a function of time while the dynamic evolution of the age dependent mortality possesses a stochastic component. The figure illustrates the behaviour of the model. There, we have chosen the year 2004 as the starting time t = 0.

Further models are under research. They can also be easily simulated with the ITWM-Asset-Liability-Management-Tool ALMSim.

1 *Simulated future evolution of the mortality rate of 65-year old male μ(65,t) with t=0 centered in 2004*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MATHEMATICAL METHODS IN DYNAMICS AND DURABILITY

- STATISTICAL MODELS FOR USAGE VARIABILITY AND DURABILITY
- SIMULATION OF MECHATRONIC SYSTEMS
- CAE-DURABILITY
- NON-LINEAR STRUCTURAL MECHANICS

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The department develops models and methods for dynamically loaded mechanical and mechatronic systems. Statistical methods and optimization processes are used to model the broad range of use cases and variants. Multi-body simulation (MBS) and finite element methods (FEM) are used for system and component analysis. In our industrial projects we examine reliability, durability, structural dynamics and system dynamics primarily in vehicle industry.

The Fraunhofer Innovation Cluster Digital Commercial Vehicle Technology (www.nutzfahrzeugcluster.de), in which the department handles overall coordination and a major share of the projects, continued its expansion. New initiatives in the subject areas of "energy efficiency" and "ground interaction simulation" are expanding our ongoing activities in the areas of system simulation, design criteria, on-board simulation, and structural mechanics with industry partners Bosch, Daimler, John Deere, Schmitz Cargobull, and Volvo. This attracted new partners like Bomag, BPW, Liebherr, and EvoBus. The Fraunhofer-Gesellschaft and the government of Rhineland-Palatinate under the heading of "Vehicle – Environment – Human Interaction" have funded additional research and methods development projects until 2013.

We develop methods to statistically model product use by customers – both for the derivation of reliability design criteria and for the optimization of other criteria that are dependent on variable use factors such as energy efficiency and fuel consumption. Statistical methods play a major role in reliability engineering and component release. At ITWM, system simulations model complete vehicles, axles, or test systems in "optimal complexity" so that not only the kinematics and motion chains, but also, in particular, the power transmission is correctly computed in advance. This involves modeling of the interactions of a great many moving components as well as the behavior of complex forces and actuators. However, the degree of modeling is limited by time and hardware resources when it comes to parameterization of the models. One of our competencies is excited invariant systems. This is where identification processes (iterative learning control) and optimal control processes as well as suitable modeling methods for the mechanical exterior contacts (tires, digital roads, tractors, plows) are developed and applied. The stresses on individual, more or less deformable components can be determined from a simulation of the system dynamics and appear as dynamic cutting forces. These reactionary strains are then transferred over to local stresses and service life estimates through structural mechanical simulation. We develop methods for the computation of service life of structures with non-linear characteristics and apply these in industrial projects. Beyond our competence in foundry process simulation, we investigate the systematic use of the results of the foundry process simulation in the component strength analyses. In the case of non-linear structural dynamics, the attention is on the severely deformable components and structures like tires, elastomers and hydro mountings, air springs, cables, and hoses. This involves different levels of modeling, from detailed FE models in continuum mechanics to simplified macroscopic models. Of major importance here is that an application-specific, optimal model complexity is selected – detailed enough show to the physical effects of interest and simple enough to be parameterized within a reasonable effort in the development process.

Dr.-Ing. Yekta Öngün, Michael Burger, Dr. Albert Marquardt, Lilli Müller, Clarisse Weischedel, Dr. Anja Streit, Urs Becker, Dr. Holger Lang, Martin Obermayr, Dr.-Ing. Gerd Bitsch, Thorsten Weyh, Dr. Andrey Tuganov, Oliver Hermanns
Oliver Weinhold, Dr. Michael Speckert, Thomas Stephan, Thomas Halfmann, Pascal Jung, Steffen Polanski, Reinhard Priber, Dr. Klaus Dreßler, Sascha Feth, Michael Kleer, Sonja Baumann, Christine Rauch, Dr.-Ing. Joachim Linn, Dr. Nikolaus Ruf

COMPARATIVE STRESS ANALYSIS FOR CABLES AND HOSES

Unexpected damage to the cable and hose assemblies in vehicles can often be traced back to a lack of attention in the design phase regarding the actual elastic behavior of the materials. Frequently, it is unclear what impact the design measure will have on the actual stress under operating conditions. This is a problem that must frequently be analyzed and evaluated in a minimum of time.

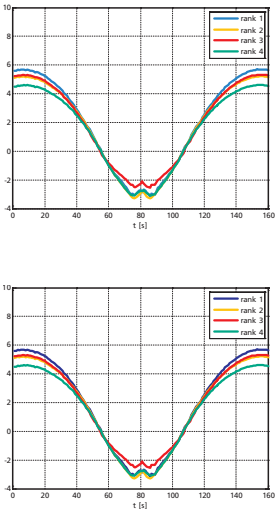
In principle, classic simulation methods like the geometric non-linear Finite Element Method (FEM), can be used to solve these problems. However, these require expert know-how and are too time consuming for routine use, especially for the examination of many variables. In contrast, the methods developed at the department Mathematical Methods in Dynamics and Durability can interactively simulate the actual, flexible, geometric non-linear behavior of cables and hoses. Models can facilitate a rapid analysis of not only the existing installation situation, but variations of it as well. Among other things, this new approach facilitates computation of the total 3d stress on flexible components and subsequent assessment of the assembly situation using established methods of load data and stress analysis. An evaluation of multiple variables through comparative analysis of the local stresses can be completed in a relatively short time.

The new method is based on the Cosserat rod theory and mechanical structure models. Special discretization approaches reduce the computational effort and facilitate the real time simulation of flexible components. With the application of special functions, the so-called warping functions, a direct reconstruction of the 3d stress tensors over time is possible using the existing forces and torques.

Established methods of load and durability analysis, such as critical cutting plane approach, the rainflow count, and the pseudo-damage computations are used for the stress assessments. In this process, synthetic Woehler lines are used and although this does not permit durability estimates, it does allow a comparison of stresses. A practical example of how the described procedure can be used is for the study of cable laying in the AUDI tailgate. The choice of the initial cable length and the installation situation (correct installation and twisted incorrect installation) were examined in terms of the effects of cable stress.

1 *Comparison of stress for different cable lengths*

2 *Comparison of installation space required for different cable lengths*



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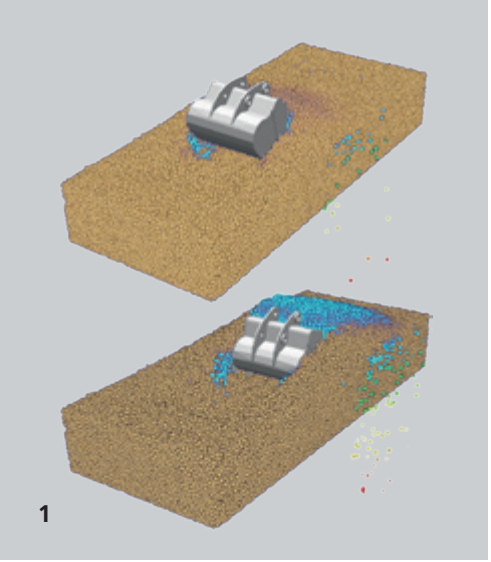

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2

GROUND AND INTERACTION SIMULATION

1 *Simulation of reaction forces while excavating rough gravel*

2 *Test setup for validation*

Besides performance and costs, reliability plays a major role in the development of construction and agricultural machinery. During operation, these machines are subject to significant external loads from the work process, e. g., excavation forces affecting an earthmover. Such loads depend not only on the type of operation but also on the design of the machine. For example, the load on an earthmover operating at a quarry is significantly greater than when it is loading a truck with bulk materials.

Measuring techniques to capture the high operational diversity and variability of the external equipment have been used in the past. Subsequently, large-scale measurement campaigns were performed and then evaluated using the influencing factor models developed at ITWM. This process facilitates a determination of the effect of individual factors, for example, type of operation or driver characteristics, on the results. The model also allows estimates of the loads on the vehicle from other usage profiles than the one used for the measurement.

The aim of the soil interaction simulation is to integrate the studies of the external work process loads into virtual product development. This allows for a comparison of the different variables under otherwise identical conditions. Various engineering design changes can be examined in terms of the different reactions to the loads on the machinery and, over the long-term, structural strengths can be tested on virtual prototypes.

To simulate the complex mechanical behavior of the soil, the Discrete Element Method (DEM) is being used in a project with Volvo CE. In this method, a model of the actual surface is constructed of rigid, spherical particles. Soil characteristics are reflected in the description of the contact conditions between particles. Material properties are determined in the lab. The respective lab test (triaxial test) results are then used to set the parameters of the contact characteristics in the simulation. In the case being studied, the forces of the simulation approximated the measured values very well. In the future, the method will be expanded to more complex materials.

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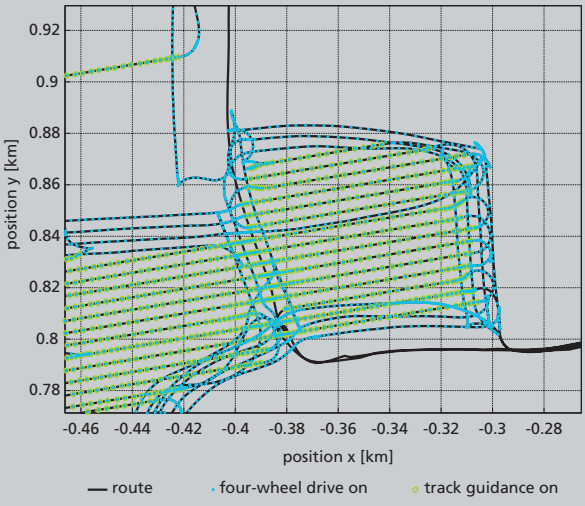


2

EFFICIENCY IMPROVEMENT IN COMMERCIAL VEHICLES

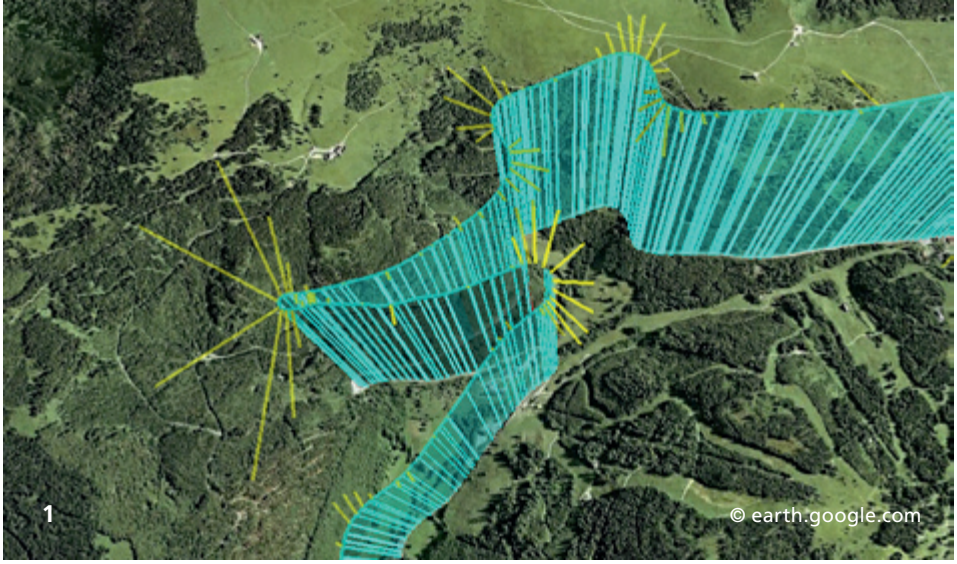
A large quantity of information about how customers drive is already available from the computing and communication equipment included in the standard production series of commercial vehicles today. In cooperation with various manufacturers, ITWM develops processes that apply this data for the optimization of vehicle design. Besides deriving a basis for the realistic assessment of operational capabilities, fuel efficiency plays an increasingly greater role. The range of applications in this area include:

- Development: New vehicle models can be better designed for actual operations right from the start.
- Sales consulting: Customers can be more accurately informed what vehicle is most appropriate for their needs.
- Fleet planning: Companies with vehicle parks can evaluate the efficiency of their equipment in various tasks and better plan which one is the best for a particular job.
- Smart controls: The fuel consumption of a modern vehicle depends not only on mechanical engineering, but also on the electronic engine controls, transmission, and other devices powered by the output. The better all of these respond to the actual situation, the better the operating efficiency.
- Driver assist systems: An individual vehicle's information system can help the driver to work more efficiently.

The wider the range of use for a vehicle, the greater is the potential gain from active control and assistance systems. Improvements in the first two points are often sufficient for trucks and buses, although for vehicles with hybrid drives an intelligent battery management system could also be quite interesting. Farm and construction machinery are employed in many different operations and, beyond power, must also deliver a substantial performance in areas like mechanics, hydraulics, or electrical consumption. This complicates the modeling, but also facilitates higher efficiency gains through intelligent technologies. A project with John Deere is developing methods to monitor and optimize the efficiency of tractors during operational use. Modeling the energy flows is combined with statistical analysis methods to study the data provided from the vehicle electronics. The system model provides a starting point for finding the optimal choice of operating variables like working speeds, transmission control, etc. The statistics are required because too little is known about the environmental influences like surface and weather conditions and so must be determined indirectly.

1 *John Deere tractor*

2 *Excerpt from measurement data*



VIRTUAL MEASUREMENT CAMPAIGNS

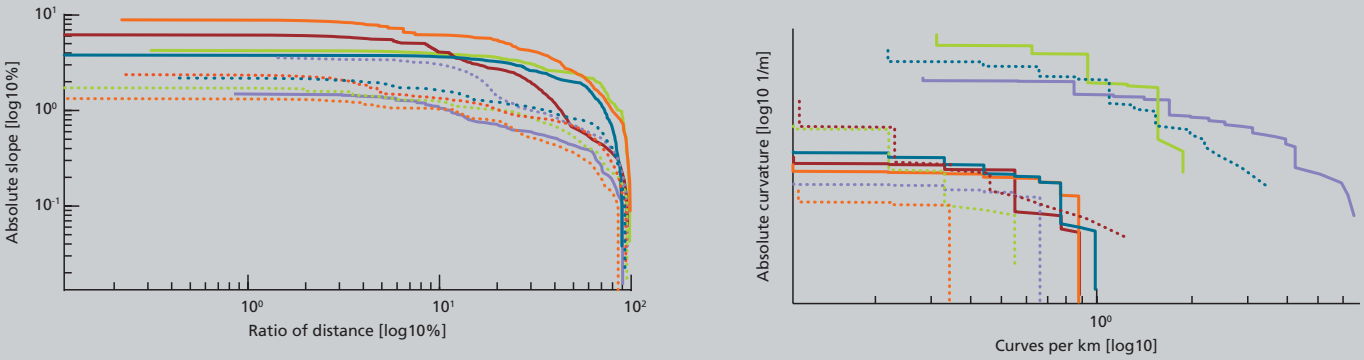
1 *Visualization from Google Earth of computed slopes and curves*

An increase in the demands on personal and commercial vehicles as well as on construction or agricultural machinery in terms of reliability, efficiency, and consumption combined with the ever-shorter development times makes it all the more important to have the most accurate knowledge possible of the operational loads and then, to use the latest computational methods in the engineering of components.

The operational loads, excluding the driver and vehicle, depend primarily on the environment (e. g., road conditions, curves, steep slopes, traffic, climate) and use (e. g., long distance or regional distribution for commercial trucks). At present the determination of operational stress is achieved by measurement campaigns performed with a comprehensive measuring apparatus. An advantage of this procedural approach is the good quality of the data obtained. The disadvantages are costs, data dependence on the measurement vehicle, and the limited scope in terms of the measured routes and the operating states.

This is precisely where the concept of the Virtual Measurement Campaign (VMC) begins. More extensive measurement trips of any length long can be computer simulated with relatively simple vehicle and driver models, assuming the relevant area map data is provided. ITWM develops a system that collects and processes the relevant local data making it accessible for the appropriate analysis. For example, curves and gradients of any random route can be computed – including traffic lights, intersections or other traffic information from map data and elevation profiles available worldwide. Information about the quality of the roads is especially important when interested in operational stability. This information is not available for every part of the world and, specifically, is often not in a form conducive to making a quantitative judgment of the effects on a vehicle. In order to use such data, the appropriate algorithms must be developed to permit the extraction of relevant information. For example, categories of stochastic processes that are useful in describing surface roughness must be identified and a picture of the broad road quality created as input to the categories.

Another example is usage: In this case, the quality of the road surface is less dominant than the topography and traffic. The topographical data is very well covered by available data sources, but it is difficult to obtain facts about the traffic situation. However, this type of data is necessary for a simulation of the speed profiles along a route. In this context, the so called micro-traffic simulation methods are important for an examination of the traffic flow at the level of a single vehicle.



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Statistical analysis plays an important role in all cases. What are the average stresses applicable for many vehicles over long driving times? What variations can be expected? How do uncertainties in the data used to describe the environment creep into the results?

Some important applications are appropriate in the analysis of diverse regions. What is the breakdown of interstate highways, state roads, or city thruways in regions A and B? Are the conditions for long distance trucking in Brazil comparable to those in India? Is a vehicle that has been engineered for sale in central Europe also appropriate for sale in Japan or South Korea? This tool provides much sounder and more focused answers to these and similar questions than was possible in the past. To supplement partially missing data (e. g., presently, data for the surface roughness is not available everywhere), the respective extrapolation algorithms are developed to permit projections for an entire region on the basis of representative, small sample area measurements.

Factor models are used to substantiate the determination of the vehicle operating environment, which facilitate the structured storage of cause variable data like road type and cargo loads. This allows an examination of vehicle stresses or wear and tear on the basis of usage (for example, by the Monte-Carlo method). In connection with these activities, algorithms to detect operating states are created from relatively simple data generally available in the vehicle (online-monitoring), which can be used to determine actual vehicle use or to automate the structuring of measurement data from a real campaign.

The immediate goal is to improve the planning of real measurement campaigns and the transferability of existing data from one region to another, so that the available data will also be useful for other markets. Over the long-term, with refinements to the vehicle and driver models, it will even be possible to perform a completely virtual measurement campaign.

2 *Automatic segmentation and evaluation of routes*

COMPETENCE CENTER HIGH PERFORMANCE COMPUTING

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

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Development and use of numerical simulation processes are the heart of the research at ITWM and the basis for all technically complex developments in industry. In many industrial sectors the demand to solve increasingly large problems is strongly growing, e. g., in seismic exploration or in life sciences. At the same time, engineers and scientists want to work interactively and more efficiently to solve their problems. Large data driven problems and interactivity are the drivers that led us to Petaflop's computers, GPU Computing and are stimulating the discussion about accelerator technology and Exaflop computing. HPC deals with the challenges associated with the algorithmic development, the implementation and the execution of compute intensive problems on HPC hardware. It is therefore positioned at the intersection between mathematics, computer science and the applied sciences. In recent years a paradigm shift has taken place at this intersection, which has by and large still not entered into practice. Over more than 10 years the increase in compute speed has simply been gained through higher clock speed. Since 2005 the clock speed stays the same and additional performance can only be gained by higher hardware parallelism. Since then we see a competition for the highest number of cores. This change in direction on the hardware side has considerable consequences for the development of performance-hungry software. An increase in performance is now only to be attained through parallelization and as the floating point performance goes to infinity the data transport is the limiting factor and determines the way we develop and implement new algorithms today. The CC HPC addressed this paradigm shift at an early stage and brought innovative new software tools for the development of parallel software to the market. The heart of these tools are the Global Address Space Programming Interface GPI, which replaces the previous MPI programming model, and an efficient library for the development of complex multi-threaded programs, the multi-core thread package MCTP. Expanding on this, new parallel programming platforms are currently being developed for large parallel computer systems. The Seismic Development and Processing Architecture SDPA implements a fault-tolerant system where domain-specific applications are developed inside a high-level graphical user interface, while the SDPA framework takes care of an efficient parallelization and throughput optimization. The SDPA speeds up the development for new applications from scratch and it is made to integrate legacy software modules at the same time. The system is intended for large parallel systems and will be used initially in the oil industry.

Since 2005 FhGFS, a new Parallel File System has been under development at the ITWM. The development started from scratch, learning from the problems and hassles with existing systems. In 2008 the first official release of FhGFS was available from the website www.fhgfs.com. A series ofsmaller installations in the oil and gas sector have confirmed the reliability of the system and first large installations have been implemented at various universities. Fraunhofer seismic imaging software enters into production in oil industry. The software packages GRT for angle domain migration and PreStack-Pro for visualisation, processing and analysis of pre-stack seismic data have fulfilled the high demands of our industry partners and are now in productive use by companies worldwide. In the scope of the ITWM Future topic "Renewable Energies" activities of various departments are bundled. The focuses of the work at the CC HPC are software systems which will manage distributed systems in electricity networks; see also www.mysmartgrid.de.

Dr. Carsten Lojewski, Alexander Neundorf, Rui Màrio da Silva Machado, Sven Breuner, Christian Mohrbacher, Kai Krüger, Frauke Santacruz, Alexander Petry, Dr. Franz-Josef Pfreundt, Benedikt Lehnertz, Pavel Frolov, Tobias Götz, Dr. Daniel Grünewald, Nikolai Ivlev, Bernd Schubert

Jens Krüger, Dr. Martin Kühn, Matthias Klein, Dr. Mirko Rahn, Dr. Abel Amirbekyan, Lena Oden, Ely Wagner Aguiar de Oliveira, Bernd Lörwald, Dr. Dimitar Stoyanov, Egor Derevenetc, Dr. Tiberiu Rotaru, Bernd Klimm, Dr. Norman Ettrich, Dr. Dominik Michel

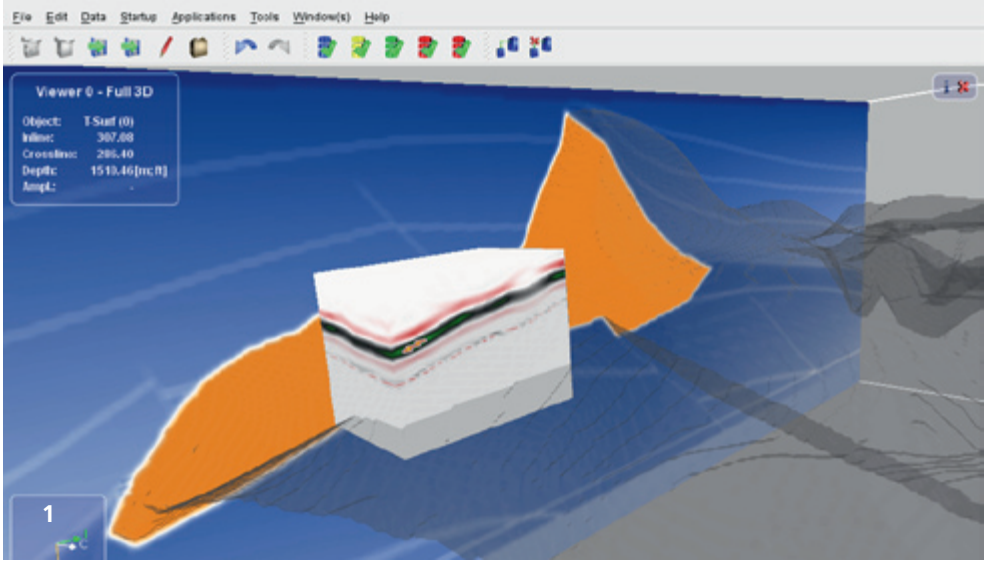
PARALLEL PROGRAMMING IN THE FUTURE: GPI AND MCTP

The development of the hardware towards massively parallel heterogeneous machines forces a paradigm shift in programming, particularly in the programming of high performance systems of the (post) petaflops era. Programming models are faced with new requirements: There is the need of a simple and flexible model that allows truly asynchronous and efficient communication between storage subsystems with different bandwidth and latency. Only then can communication and computation take place at the same time, a key requirement for scalable software. The MPI standard, which was established in the 1990th, is no longer suitable here.

The CC-HPC has met this challenge and developed two simple, robust and scalable programming interfaces: GPI and MCTP. At the level of cluster nodes our Global Address Programming Interface (GPI) enables highly efficient communication with minimal latency. Building on the capabilities of modern interconnection networks such as InfiniBand and RoCE the GPI makes a partitioned global address space (PGAS) available to the application. Cluster nodes can access memory of other nodes independently (one-sided), fully asynchronous (no load on the cores), without temporary copies (zero-copy) and with maximum bandwidth, both for reading and for writing. This basic functionality is complemented in GPI with a number of other functionality: Extremely fast collective operations (e. g. barriers), atomic counters (atomic across the cluster) or extensive environmental tests are just a few. The MPI style programming with sending and receiving messages is also supported. GPI adds a completely new type of passive communication, which is far beyond what is possible with MPI. GPI is completed by a fault tolerant execution environment.

Within a node GPI is complemented by our multi-core threading Package (MCTP) to give a complete environment that allows the development of scalable software based on a single (thread) model. The MCTP provides functions for dealing with parallel threads and thread pools. It is a state of the art implementation and is currently the only library that takes into account specific hardware situations (NUMA layout). This results, for example, in synchronization primitives with latencies that are orders of magnitude smaller than the latencies in any other threading package.

Both GPI and MCTP have proven their quality and robustness since years when used as core components of our software products, which are also in heavy use at customer sites in the industry. In 2010 the CC-HPC has started the launch of GPI and MCTP as standalone products. At several international exhibitions we have seen great interest. Meanwhile there are evaluation installations in several large national computing centers.



INTERACTIVE MIGRATION

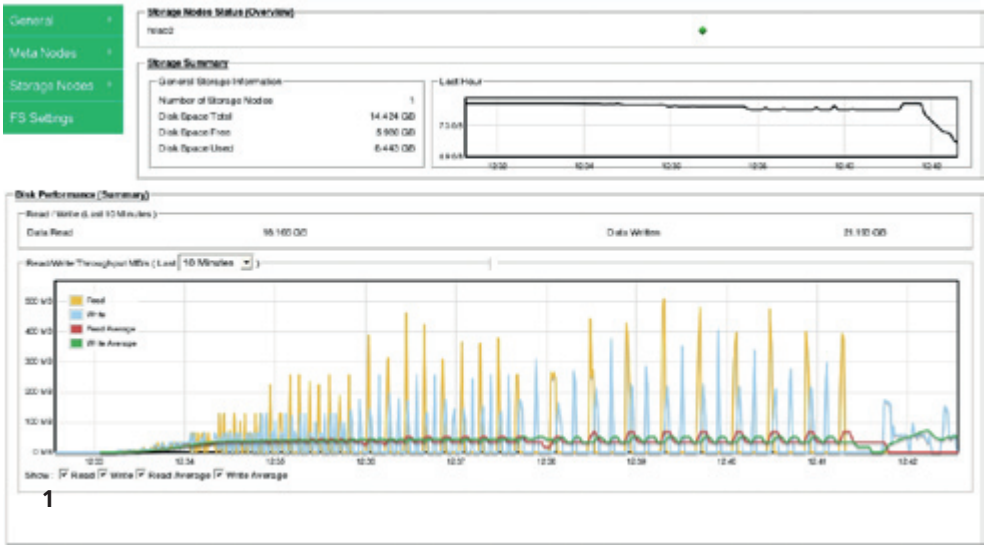
1 *GUI for interactive migration: Simultaneous display of saltdome (orange), surface of salt dome (gray-transparent), velocity model (blue), and migration result inside the selected rectangular subvolume*

Seismic migration methods produce images of the subsurface, e. g., for exploring oil and gas reservoirs. The quality of these images largely depends on the accuracy of the migration velocity models. The latter are a priori unknown and must be obtained by inversion processes. Conventional inversion methods derive criteria for model updates from the differences between partial migration results. However, they fail in more complicated situations, often in these areas of the subsurface which contain salt bodies. These impose large complexity to the propagation of seismic waves, rendering the inversion of the shape of the salt domes impossible. In such cases, it only remains to the geoscientific users to change the shape of the salt bodies by trial and error methods. Then the impact on the migration results can be evalueted in order to judge due to geologically relevant criteria, and whether the result is improved and thus the velocity change can be accepted or not.

Commissioned by the company Statoil, ITWM develops a compact software solution for this application. It comprises the components of ultra-fast migration, efficient and flexible visualization, and editing of complex geological bodies for the task of interactive migration.

The high speed of the migration is achieved by so-called beam techniques. These process groups of traces by bundles of rays simultaneously rather than migrating individual seismic traces to depth using single rays. High level of parallelization, based on our propriatary GPI-software, data selection and compression methods provide acceleration rates of magnitudes compared to standard methods.

The migration is controlled by a graphical user interface that also allows the visualization of the velocity models, the migration results, and the salt bodies. For the latter we use volume rendering techniques for voxel-based representations; salt dome surfaces are shown as triangular meshes. Tools for conversion between surface and volume representations of the salt bodies and multiple editing modes for the salt dome surfaces, together with sophisticated navigation and selection mechanisms allow to process production scale projects with seismic data from several 100-square-mile areas migrated to subsurface areas of the scales at some 100 cubic kilometers with a resolution of about 10 meters. The correspondingly high demands on the seismic algorithms as well to the visualization can only be coped with by very efficiently designed parallelization and optimization of all the sub-processes involved.



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SCALABLE STORAGE WITH THE FRAUNHOFER PARALLEL FILE SYSTEM

With the constantly increasing performance of modern processors and network technologies, which enable integration with increasingly larger computer clusters, the demand for increasingly realistic and detailed simulation results is also growing. Such simulations also require work with large data sets, which now often lie in the range of several hundred gigabytes or even in the terabyte range. In the process, however, it is problematic that the performance of hard discs lies significantly below that of the remaining system components, so that the run-time of a compute job is often primarily determined by the speed of the hard disc access.

In order to counteract this, the CC HPC has been working on the parallel file system FhGFS for several years now. With this file system, the individual files are distributed accross multiple servers chunk by chunk and, in doing so, can be read or written in parallel. This method enables the processing of data sets at many times the conventional speed and thereby has an immediate, positive effect on the length of time until reaching the calculation result. Along with a very good scalability of the system, the developer team placed major importance on uncomplicated use through the preparation of graphic management tools and a high degree of flexibility in the installation. In this way, FhGFS makes it possible to use separate servers as a common parallel storage in a cluster as well as to connect the hard discs of the cluster compute nodes themselves in this manner. In addition, the distribution pattern of the data can be flexibly adapted to the requirements of users, such as geographically separate data centers, in order to further reduce the access time to the data. In recent years, cooperation with partners and customers from industry and research organizations showed that FhGFS can deliver a significantly better throughput rate for typical workloads than comparable commercial solutions. That is why FhGFS was chosen to manage the storage of one of the world's fastest supercomputers, the LOEWE-CSC, which is located in Frankfurt/Main. This system consists of more than 800 compute nodes and can read and write data at a rate of more than 10 GB/s.

Currently, the file system is in use on diverse clusters with a size of several hundred compute nodes. Next year, the work on a high-availability mode will be completed and support for Microsoft Windows will follow. This will make the file system also attractive to users outside of the HPC area, for example as a fail-safe project storage or for home directories.

FhGFS can be downloaded free of charge at **www.fhgfs.com**. Optional support is also available.

1 *Graphical tools make FhGFS administration and monitoring easy and intuitive.*

Fraunhofer FS

1 © Deutsche Börse

2

PARALLELIZATION, PERFORMANCE, AND GREEN IT

1 *Financial Market, Derivatives Acceleration Faktor: 20*

2 *Sequence Correlation Benchmark, Acceleration Faktor: 130*

Whether in financial markets or in life sciences, the absolute performance and throughput of computationally intensive applications plays an increasingly important role for the business. The Competence Center for High Performance Computing has developed specific competences to optimize software for multi-core processors and accelerators. The main branches it focuses on are financial markets, oil & gas industry, life sciences and engineering.

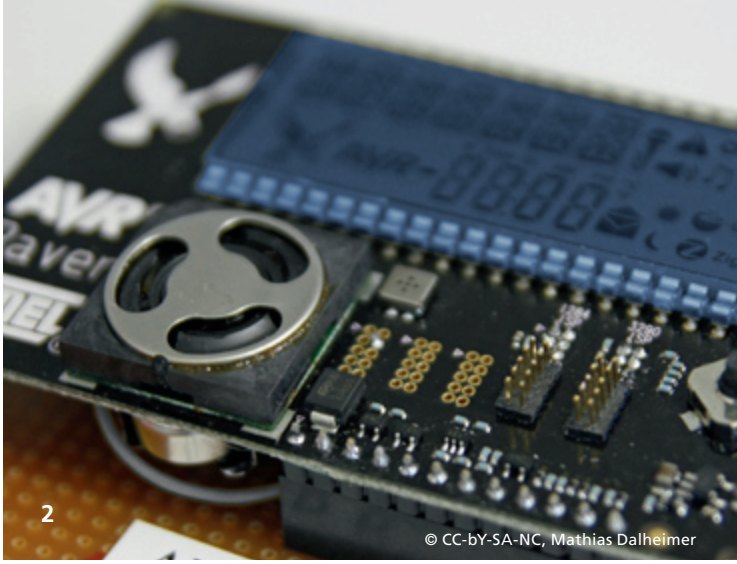
Due to the transition to multi-core architectures, it has become increasingly difficult for the typical developer in the company to design efficient software . This refers both to the single-core performance as well as the multi-core performance. In both cases a fundamental understanding of the hardware structure and the parallelization methods is now necessary.

The two pictures represent applications that are typical candidates where code optimization and parallelization expose a huge potential. Without modification of the core numerics, we have been able to accelerate a broad spectrum of applications by a factor 3 – 10 per core. Modifications in the mathematics and numerical analysis are then responsible for a factor of 130 in the Sequence Correlation benchmark.

What is the result of an application running 100 times more efficiently: The Life Science code needs instead of 10 days on our 1 000 core computer either 1000 days on the same machine or a 100 000 core computer. In both cases, the electricity costs to operate the hardware are extremely high. We have a similar situation for applications in the financial markets. Alone the savings in energy costs comfortably let you buy new, more efficient computers. The cost of optimization is rather negligible.

In this context the keyword Green IT, which is now often used by hardware vendors really makes sense. An optimal data center can save 50 % energy, but a new hardware system saves energy only if the application is adapted, that means it was parallelized. Efficient parallelization and code optimization can deliver more than an order of magnitude of efficiency .

At the Competence Center for HPC, we work directly with the processor manufacturers (IBM, INTEL, NVIDIA), in order to optimally adapt our customer applications. In addition we rely on our own parallelization tools to bring our innovations from research into industrial practice.



SMART GRIDS – INTELLIGENT ENERGY SOLUTIONS

The integration of alternative energies (AE) from wind power stations or photovoltaic plants poses significant challenges to our power distribution grids. New ways to integrate the fluctuating power coming from alternative generation plants are necessary in view of the limited capability to store electrical power. Essentially, there are two options: Power storage sources like lithium-ion batteries decentrally installed to capture the additional energy. Or, the alternative may be to operate devices only when sufficient energy is being produced. Both options result in the improved integration of AE power in our existing power grids.

The "mySmartGrid" project takes on the second of these approaches: Control technology should be able to supply power to high consumption requirements like freezers and heat exchangers at times when there is a large supply available in the grid. In Kaiserslautern and surrounding areas, up to 1000 households and SMEs are being equipped with the appropriate technology. The study will measure the electrical power consumption and present the results to the participants in a way that enables a better understanding of their own power requirements. The aim of the project is to create a virtual consumer, that can be used to stabilize the power grid. Access to all project results is free and based on open-source development. We are working together with local power utilities like the Stadtwerke Kaiserslautern, as well as with equipment manufacturers.

The second project "myPowerGrid" complements the first project as we examine the possibilities to store power in lithium ion batteries. For example, excess power generated by wind power stations could be fed into the grid at a later time during periods when the wind is not blowing. The technology this requires is being developed in cooperation with power utilities and equipment manufacturers. Our main contribution is in the coordination of the distributed energy storage sources within the power grid, which have to be appropriately regulated. In the process, not just the fluctuating production performance must be considered, but also the limitations regarding the battery loading and discharge properties.

1 *Power from wind power stations is not suited to long term planning. Our power grid must become more flexible, so it will be able to store more power generated by renewable energy sources.*

2 *To regulate the household devices, they must be connected to a bus control system. ITWM is developing OktoBus, an open-source bus system that can be integrated directly with the existing home network and upgraded at a reasonable cost.*

FRAUNHOFER-CHALMERS RESEARCH CENTER FOR INDUSTRIAL MATHEMATICS FCC

- GEOMETRY AND MOTION PLANNING
- COMPUTATIONAL ENGINEERING
- RELIABILITY AND RISK MANAGEMENT
- SYSTEM BIOLOGY AND BIOIMAGING

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FCC has since start 2001 completed more than two hundred industrial and public projects. We have successfully cooperated with more than seventy 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 2010 both founders decided to continue their present annual joint support of one million euros for another five years 2011–2015. At the same time Fraunhofer expressed the wish to widen the scope of the cooperation. Our mission is to undertake and promote scientific research in the field of applied mathematics to the benefits of industry, commerce, and public institutions. We do this as a business-making, non-profit, Swedish institution. The year 2010 was again a successful one, with annual turn-over reaching all-time high.

We note a continued increase of public projects in absolute and relative numbers. At the same time the industrial income has levelled out, with industry to a large extent present as contracted partners in the public projects. We expect it will take two to three years to re-establish the normal level of an industrial income around forty percent through a campaign aiming at a broader base of industrial clients including small and medium-sized companies. Together with our partners Chalmers and the Fraunhofer industrial mathematics institute ITWM we cover a wide range of applications. In 2010 we have intensified our cooperation further, including joint actions with all ITWM departments, with Chalmers Wingquist Laboratory, Chalmers Systems Biology, Chalmers Mathematical Sciences and GMMC (Gothenburg Mathematical Modelling Centre), Chalmers Fluid Dynamics, and Chalmers Biomedical Engineering.

In 2008 we started the industrial partner group IPG as a successor of the former Swedish Association of Industrial Mathematics STM. The group meets two to four times a year in Kaiserslautern and in Gothenburg to propose a research programme from research scenarios, industrial scenarios, and making a synthesis. The first year was on inverse problems, parameter identification and optimization, the second year on uncertainty, reliability, risk and quality, with research scenarios presented by GMMC, and the third year 2010 was on visualization.

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 2010 the department continued and extended several public projects, e. g., on 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.

The department Computational Engineering and Design has expanded its work on multi-physics applications involving fluid-structure and fluid-electromagnetics interaction, in particular through projects with Swedish and other European industrial partners together with the ITWM departments Optimization and Flow and Material Simulation. The department runs a three-year project on innovative simulation of paper with Swedish paper and packaging industry, in 2010 supported by a companion project on dynamic fiber network modeling in a finite element setting through the Gothenburg Mathematical Modelling Centre GMMC. The department is a key partner in the project on virtual paint mentioned above.

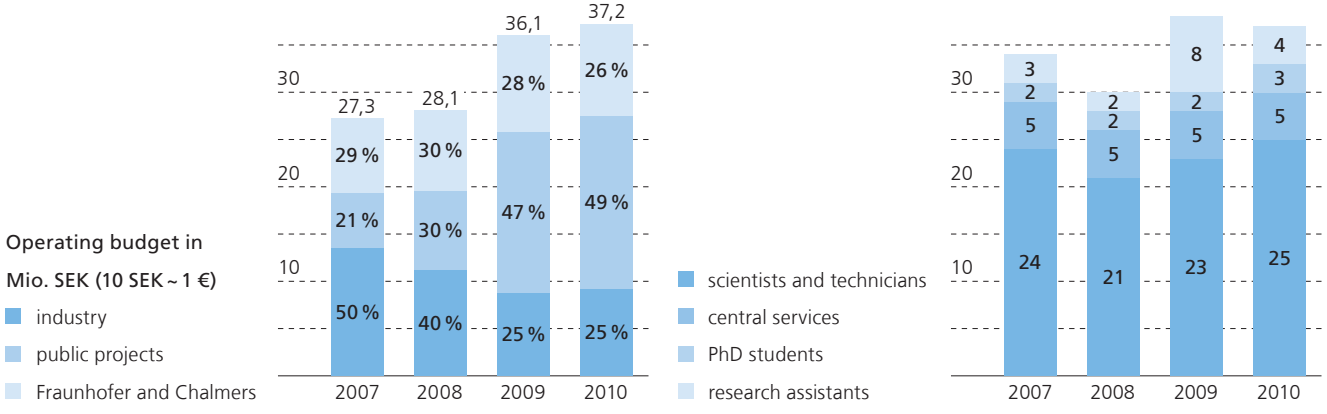
The department Reliability and Risk Management has focussed on fatigue life and load analysis of mechanical structures in, e. g., automation and automotive industry. In 2010 we coordinated a pre-study "Virtual Measurement Campaigns for Trucks" with the Chalmers Stochastic Centre, Fraunhofer ITWM Dynamics and Durability, SP Technical Research Insti-

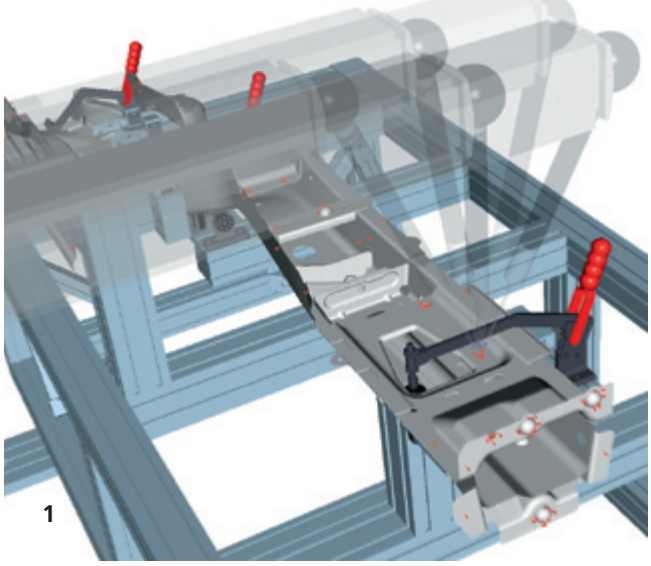
tute of Sweden, and five industrial partners from Germany, the Netherlands, and Sweden. This department was closed in the mid of the year due to unsatisfactory economic development and the main project following the pre-study will be run by a consortium led by Fraunhofer ITWM.

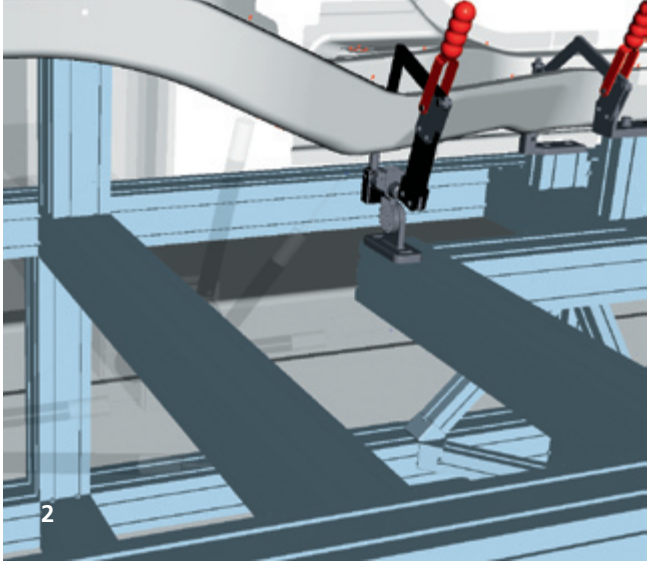
The department Systems Biology and Bioimaging has continued to grow, in particular through EU projects. Our cooperation with the ITWM department System Analysis, Prognosis and Control has intensified through a strategic project on integration of systems biology, biotechnology, mathematics, and image processing in fundamental animal cell protein production. Work on interactive pharmacokinetics and pharmacodynamics and the software Maxsim2 developed for pharmaceutical industry is presented below.

Last year we were fortunate to recruit six 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. We believe in a model where 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. If a proper project then appears, which would naturally include a PhD student, we are well positioned to offer the project a candidate who would contribute significantly from start, and the interested staff member a possibility for bringing her or his education one step further. Seven of our employed MScs have started PhD studies in this way: five at Chalmers and two on leave abroad.

In 2008 we initiated a campaign to offer an interesting option to Chalmers students while boosting our base for future recruitments. We invite master students from a handful of Chalmers and Gothenburg University international programs with a mathematical profile to information meetings "Earn Money on 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 in the Centre, and to do master thesis projects at the Centre with joint supervision from Chalmers and FCC. In 2010 we had thirteen Swedish students and twelve students from abroad working on this type of contract.







EFFICIENT GEOMETRY INSPECTION AND OFF-LINE PROGRAMMING

1 Feature accessibility analysis resulting in five different collision free probe configuration inspection alternatives

2 An automatic generated collision free path between two features containing a non trivial necessary probe change in the middle.

3 An optimized collision free inspection sequence for 20 features (115 points) calculated by IPS.

4 Simulated measuring cell

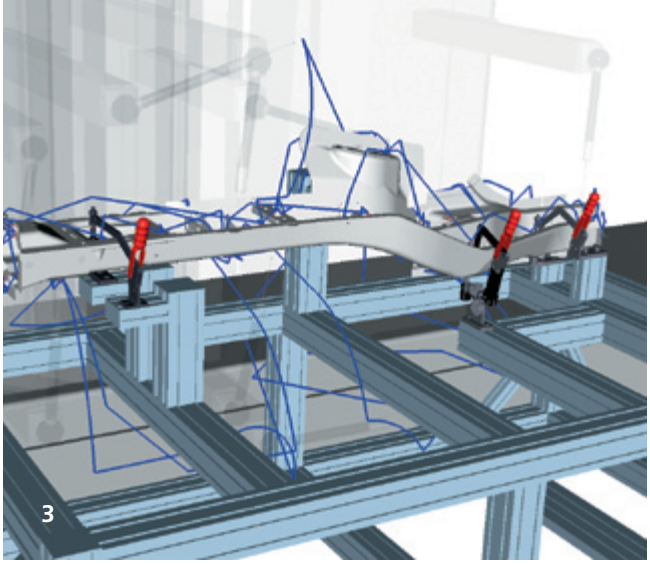
Pictures: © VOLVO

Volvo Cars is now implementing a new process and software support based on RD&T and IPS for Inspection Preparation and Automatic Off-line Programming of CMM (Coordinate Measuring Machines). The return of investment will be faster inspection preparation, programming and improved measurement equipment utilization. The implementation is based on validated research results from FCC, Wingquist Laboratory at Chalmers and SWEREA IVF within the VINNOVA's MERA program.

Since variation is inherent in all production processes, consistent efforts in styling, design, verification and production aiming at less geometrical variation in assembled products, is a key to shortening development time of new products, as well as for choosing an efficient and resource-economic production process. The activities aiming at controlling geometrical variation throughout the whole product realization process are called the geometry assurance process. The figure shows a general model for product realization consisting of a concept phase, a verification phase and a production phase. In the concept phase the product and the production concept are developed. Product concepts are analyzed and optimized to withstand the effect of manufacturing variation and tested virtually against available production data often based on carry over type of inspection. In this phase, the concept is optimized with respect to robustness and verified against assumed production system by statistical tolerance analysis.

The visual appearance of the product is optimized and product tolerances are allocated down to part level. In the verification and pre-production phase the product and the production system is physically tested and verified. Adjustments are made to both product and production system to adjust errors and prepare for full production. In this phase inspection preparation takes place. This is the activity when all inspection strategies and inspection rules are decided. In the production phase all production process adjustments are completed and the product is in full production. Focus in this phase is to control production and to detect and correct errors by analyzing inspection data.

As we can see, it is necessary to feed the geometry assurance process with reliable inspection data in all phases which makes the inspection preparation and measuring an extensive and important activity. At Volvo Cars a new vehicle program is inspected with typically 700 inspection programs containing up to 25 000 features. The inspection preparation contains three steps:



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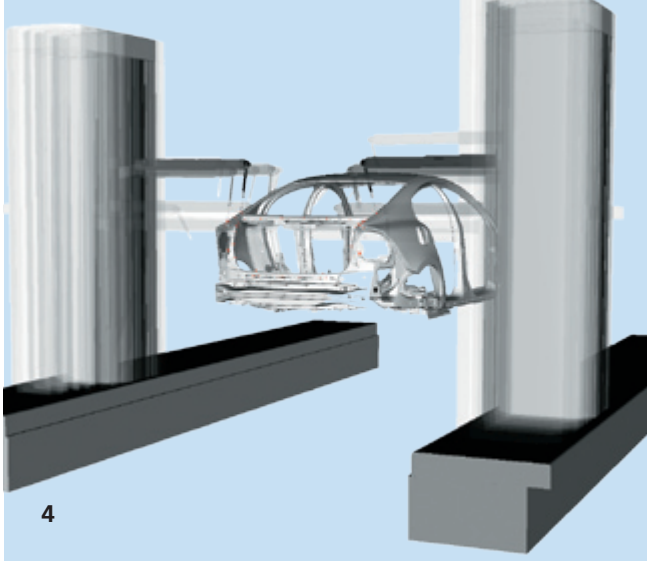

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- the inspection task is defined by breaking down product and process requirements to geometrical inspection features, e. g., a hole or a slot, on part and subassembly level

- the inspection rules defines how a feature should be measured, i. e., number of points, local measuring coordinate systems, and allowed probe configurations

- the final step is to program the motions and sequence of the CMMs that performs the actual measurement.

The automatic CMM programming contains three main math based algorithms for motion planning and combinatorial optimization. The first step is a feature accessibility analysis to find a set of probe configurations of minimum size that can reach all inspection points with collision free CMM configurations. This can be done by solving a binary LP problem.

The next technology used is path planning where the collision free CMM motions are generated by automatically finding via points and probe reorientations between the inspection features. Complete path planning algorithms, which always find a solution or determine that none exist, are of little industrial relevance since they are too slow. In fact, the complexity of the problem has proven to be PSPACE-hard for polyhedral object with polyhedral obstacles. Therefore, sampling based techniques trading completeness for speed and simplicity is the choice. Inspired by both the two most popular probabilistic methods FCC has since 2003 developed a novel deterministic path planning algorithm implemented in the IPS software.

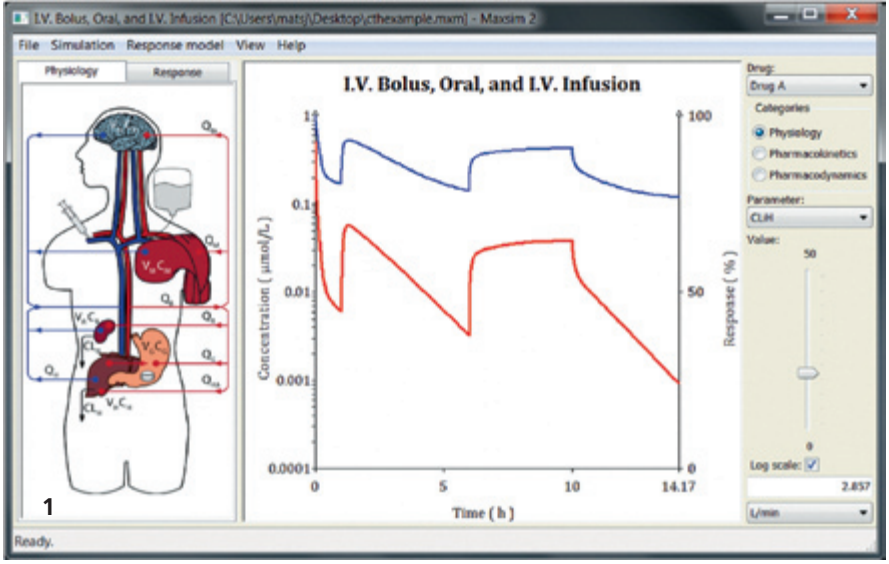
The last step is sequencing where it is decided in which order and with what probe configuration the CMM should inspect to minimize cycle time. This is a generalization of the classical Traveling Salesman Problems (TSP) which has been solved by a new direct method for grouped problems with node alternatives.

IPS®

IPS is a math based tool for automatic verification of assembly feasibility, design of flexible components, motion planning and optimization of multi-robots stations, and simulation of key surface treatment processes. IPS succesfully implements the potential of the virtual world.

RD&T Technology

RD&T is a tool for statistical variation simulation that allows manufacturing and assembly variations to be simulated and visualized long before any physical prototypes are being made. It supports the geometry assurance process in all its phases.



1 *The graphical user interface of Maxsim2 showing a simulation of plasma drug concentration (red) and drug effect (blue) after three consecutive dose administrations: intravenous bolus, oral, and intravenous infusion, respectively. The slider, in this example, controls hepatic clearance, i.e., how fast the liver is able to remove the drug from the blood. Changes in this parameter are reflected in real time in the corresponding changes of the curves in the time-concentration/effect diagram.*

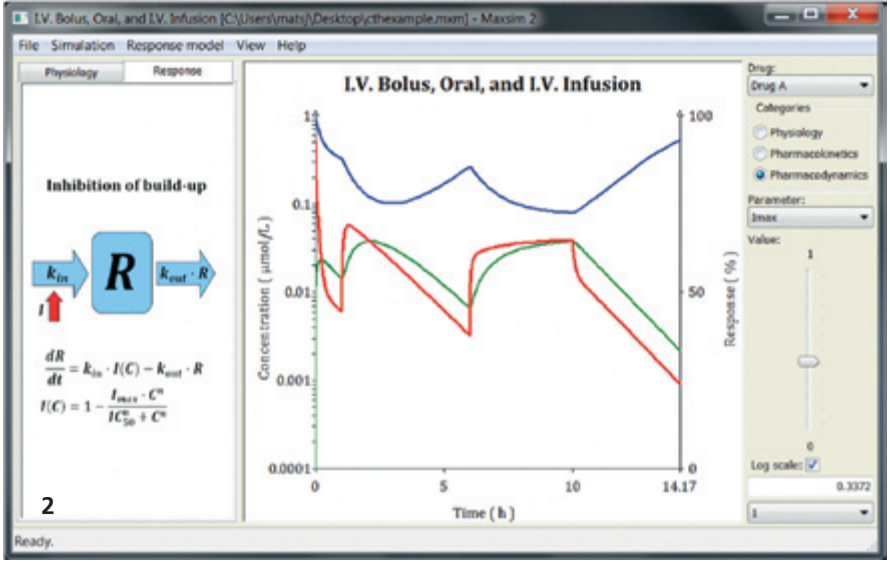
INTERACTIVE PHARMACOKINETICS AND PHARMACODYNAMICS

Mathematical modeling and simulation of what the body does to a drug after administration, such as its absorption, distribution, metabolism, and excretion, also known as pharmacokinetics, or models of what the drug does to the body, i.e., how the drug concentration is translated into a medical effect, also known as pharmacodynamics, are of increasing importance in drug development. The explanation is to be found in the promise of reduced costs and accelerated drug development due to better experimental design, improved understanding of results, and models of stronger predictive power.

The aim of the Maxim2 project is to develop a software platform for simulation of the temporal behavior in pharmacological, pharmacodynamic, and pharmacokinetic processes. The models are physiological flow models, which means that the pharmacokinetic and pharmacological processes are defined in terms of physiologically, anatomically, and biochemically interpretable parameters and mechanisms. These models are used in medical applications to describe the potency or efficacy of a substance and how it is transported and distributed via the blood to different organs in the body as a function of time. Pharmacokinetics can for example be used in medical applications to calculate optimal dosage for different therapeutic situations.

Each organ is represented by one or several compartments, which are interconnected by blood flows. These models are excellent tools for real-time presentation of the interplay between physiology, pharmacology, and pharmacokinetic processes. Traditionally empirical models, such as one and two compartment models, have been the most common types used in pharmacokinetic or pharmacodynamic (PKPD) applications. The increasing need for mechanism-based models calls for more detailed models and models with better predictive power. Here so-called physiologically based pharmacokinetic/pharmacodynamic (PBPKPD) modeling and simulation offers an oftentimes excellent tradeoff between too empirical models and too detailed partial differential equation based models.

The resulting software, developed within the Maxsim2 project is an easy to use, intuitive, and interactive application for physiologically based pharmacokinetic and pharmacodynamic simulation. The user interacts with the model and runs simulations using sliders, check boxes, and number fields. Physiological parameters such as organ sizes/volumes, tissue-to-blood partition coefficients, pharmacodynamic parameters, and parameters related to absorption and dosage regimens can be changed, which in real time is mirrored by changes of the temporal concentration profiles shown in a plot. This interactivity and direct feedback of "what-if" scenarios gives the user a good physiological understanding for how different parameters impact the



2

concentration-time or response-time courses; an understanding which has a large impact both from a therapeutic perspective as well as health economics perspective.

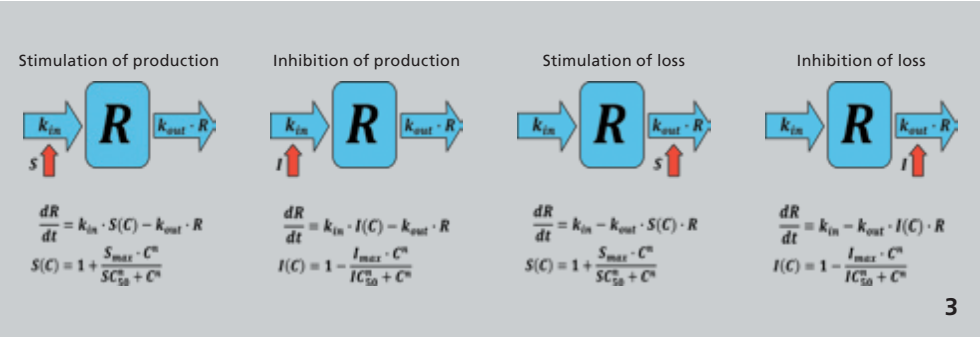
The user interface of Maxsim2 makes it easy to specify different dosage schemes such as single dose, repeated dose, or varying amounts of dose but also specifying different dosage regimens such as oral, intravenous bolus, intravenous infusion, or combinations.

The pharmacodynamic models available in Maxsim2 are both instantaneous concentration-response models and indirect concentration-response models also known as turnover models. The indirect models include both inhibition and stimulation of build-up and loss, respectively. The instantaneous models feature both stimulatory and inhibitory sigmoidal Emax models.

Using state-of-the-art graphical user interface controls, it is easy to set up simulation scenarios such as repeated oral dosage of a specific compound to study the dynamic effect of a missed dose as well as a "double dose" compensation – under what conditions does this lead to toxic effects? Or, what is the difference in temporal profiles of the plasma concentration of the drug given an oral dose, intravenous bolus dose, or intravenous infusion for a limited period of time.

We envision Maxsim2 as an ideal application for both educational and commercial use where thorough understanding of pharmacodynamic and pharmacokinetic interplay is important. For more information please visit www.maxsim2.com

2 *A simulation of plasma drug concentration (red) and muscle tissue drug concentration (green); the effect is modeled by a so-called indirect response model with inhibition of build-up giving the drug effect (blue).*



3 *Indirect pharmaco-dynamic response models*

TALKS

Ackermann, Heiner
A Collaboration Platform for Freight Carriers
Lissabon (P), July; Salzburg (A), April

Adorf, Hendrik; Grünewald, Daniel
GPI instead of MPI
HPC-Tools Workshop, Stuttgart, September

Altendorf, Hellen
3D Characterization of Fibre-Reinforced Composites
Composite2010 - 23rd International Workshop Research in Mechanics of Composites, Bad Herrenalb, November

Altendorf, Hellen
3D Directional Mathematical Morphology for Analysis of Fiber Orientations
Workshop Image Processing – Trends and Applications, Kaiserslautern, March

Altendorf, Hellen
Modeling Fiber Reinforced Polymers
IWAP - 5th International Workshop on Applied Probability, Madrid (E), July

Altendorf, Hellen
Modeling Fiber Systems using Random Walks
3rd International Workshop: 3D Imaging, Analysis, Modeling and Simulation of Macroscopic Properties, Fontainebleau (F), April; ECCM IV – 2010 European Congress on Computational Mechanics: Solids, Structures and Coupled Problems in Engineering, Paris (F), May; 16th European Conference on Mathematics for Industry, Wuppertal, July

Altendorf, Hellen
Morphological Analysis of Random Fiber Networks with Thresholded Quasi Distance
33ème journée ISS France, Paris (F), February

Andrä, H., Rief, St., Glatt, E.
Strukturgenerierung und Simulation des mechanischen Verhaltens von Papier
5. Meeting des PTS-Forschungsforums, Heidenau, October

Andrä, Heiko; Krzikalla, Fabian
Multiscale Simulation of Viscoelastic Behavior of Fiber-Reinforced Plastics
1st International Conference Multiphysics Simulation, Bonn, June

Ankirchner, Stefan; Dimitroff, Georgi; Heyne, Gregor; Pigorsch, Christian
Cross hedging with a cointegrated proxy
AMAMeF-Workshop, Berlin, September

Arne, Walter; Marheineke, Nicole; Wegener, Raimund
Asymptotic Models of Different Complexity for Viscous Jets and their Applicability Regimes
ECMI 2010, Wuppertal, July

Augustin, Matthias; Ilyasov, Maxim; Möhringer, Sandra; Ostermann, Isabel; Punzi, Alessandro
Die Erde im Wandel – eine mathematische Herausforderung am Beispiel der Geothermie
Tag der Mathematik 2010, TU Kaiserslautern, June

Bartkowski, Konrad; Iliev, Oleg; Latz, Arnulf; Zausch, Jochen
On Numerical Simulation of 1D Problems describing Transport Processes in Li-Ion Batteries
Int. Conf. Num. Meth. Appl. Borovetz (BG), August

Becker, Jürgen; Wiegmann, Andreas
Numerical Determination of Effective Material Properties of Porous Media
5th Int. Conf. on Multiscale Materials Modeling, Freiburg, October

Becker, Jürgen; Wiegmann, Andreas
Pore-Scale Modelling of Porous layers in a PEFC
7th Symposium on Fuel Cell Modeling and Experimental Validation, Lausanne (F), March

Becker, Jürgen; Wiegmann, Andreas
Predicting Transport Properties of Porou Layers Based on Pore-Scale Models
Int. Symposium on Transport in Porous Materials, Microscopy and Modelling, Villigen (CH), August

Becker, Jürgen; Wiegmann, Andreas
Virtual Material Design of PEM Fuel Cell Layers
First International Conference on Materials for Energy, Karlsruhe, July

Becker, Jürgen; Wiegmann, Andreas; Schulz, Volker P.
PEFC Gas Diffusion Layers: Effective Properties and Compression Effect
217th ECS Meeting, Vancouver (CDN), April

Bos, Peter; Rieder, Hans; Dillhöfer, Alexander; Spies, Martin
Entwicklung eines RubyOnRail-Servers für die Web-basierte Fernsteuerung von bildgebenden Aus- und Bewertungsmethoden in der ZfP
DGZfP-Jahrestagung 2010, Erfurt, May

Breuner, Sven
FhGFS - The Fraunhofer Parallel File System
DESY Computing Seminar, Hamburg, December

Burger, Michael
Invariant Loading for full Vehicle Simulation
ECMI 2010, Wuppertal, July

Burger, Michael; Speckert, Michael; Dreßler, Klaus
Optimal Control of Multibody Systems for the Calculation of Invariant Input Loads
1st Commercial Vehicle Technology Symposium, Kaiserslautern

Burger,Michael; Speckert, Michael; Dreßler, Klaus
Optimal Control Methods for the Calculation of Invariant Excitation Signals for Multibody Systems
The First Joint International Conference on Multibody System Dynamics (IMSD 2010), Lappeenranta (SF)

Burns, Patrick; Erlwein, Christina; Ruckdeschel, Peter
Finance with R
Fraunhofer-OptiRisk-Workshop, Brunel University, London (GB), November

Cheng, Liping; Rief, Stefan; Wiegmann, Andreas
Simulation of nano fibers and filtration processes
10. Symposium »Textile Filter«, Chemnitz

Contreras, Bare, Zoufine, Daniel; Nam, Alexander; Orlik, Julia
Asymptotics for Thin Fibers Being in Contact
GAMM-Jahrestagung 2010, section Short-8: ‚Multiscales and Homogenization', Karlsruhe, March

Dalheimer, Mathias
Cloud Computing: A viable Option for Enterprise HPC?
Cetraro HPC Workshop, Cetraro (I), June

Dalheimer, Mathias
Demand Side Management mit mySmartGrid
Easterhegg 2010, München, April

Dalheimer, Mathias
mySmartGrid – das intelligente Stromnetz
Seminar CCC, Mannheim, January und Maynz, February; Radiointerview in der Sendung "C-RaDaR", Darmstadt, March

Dalheimer, Mathias
mySmartGrid: Demand Side Management im Stromnetz der Zukunft
Metalab, Wien, October

Dalheimer, Mathias
Power to the People
MetaRheinMayn Chaosdays, Darmstadt, September 2010 und Symposium "Smart Grids und virtuelle Kraftwerke", Maynz, November

Date, Paresh; Erlwein, Christina; McCabe, Brendan; Messina, Enza; Ponomareva, K.; Ruckdeschel, Peter
Application of hidden Markov models and filters to financial time series data
Fraunhofer-OptiRisk-Workshop, Brunel University, London (GB), November

Debnar, Angelika; Alaerts, L.; Spies, Martin; Minogue, Patrick; Epineau, C.
Recent Experiences with Ultrasonic Inspection of Baffle Former Bolts

8th International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurised Components, Berlin, September

Debnar, Angelika; Bonitz, Frank; Spies, Martin
Prüfung der Kernumfassungsschrauben in Druckwasserreaktoren
DGZfP-Jahrestagung, Erfurt, May

Desmettre, Sascha
Optimal consumption, own-company stockholding and work effort preferences of an unincentivized executive
Stochastic Analysis Seminar, University of Oslo (N), February

Desmettre, Sascha; Gould, John; Szimayer, Alexander
Own-company stockholding and work effort preferences of an unconstrained executive
6th World Congress of the Bachelier Finance Society, Toronto (CDN), June

Desmettre, Sascha; Szimayer, Alexander
Work effort, consumption and portfolio selection: When the occupational choice matters
5th General Conference on Advanced Mathematical Methods for Finance, Bled (SLO), May; 3rd European Summer School in Financial Mathematics, Paris (F), August

Didas, Stephan
Image Denoising and Simplification with Higher Order PDEs
Workshop Variational PDEs and level set methods in image processing and shape optimization, Obergurgl (A), April

Diffo, Patrick; Wulf, Peter; Olawsky, Ferdinand; Hietel, Dietmar; Breuer, Michael
Dynamics of finite fibers exposed to a spray field in the polyurethane fiber reinforced composite spray molding manufacturing process
1st Conference on Multiphysics Simulation, Bonn, June

Dillhöfer, Alexander; Rieder, Hans; Spies, Martin
MMC-USIS - Entwicklung eines kompakten LAN-basierten Prüfsystems für die automatisierte Ultraschallprüfung, SAFT-Bewertung und 3D-Visualisierung
DGZfP-Jahrestagung, Erfurt, May

Dimitroff, Georgi
Aspects of the LIBOR Market Model
Fraunhofer-OptiRisk-Workshop, London (GB), September

Dimitroff, Georgi
Hedging index options with futures
Universität Bonn, December

Dreyer, Alexander
Combining interval and Gröbner methods for verification of digital systems
Schloss Dagstuhl - Leibniz-Zentrum für Informatik, July

Dreyer, Alexander
Interfacing with PolyBoRi and Python from Singular
Sage Days, Kaiserslautern, July

Efendiev, Yalchin, Iliev, Oleg; Steiner, Konrad
Multiscale Approaches for Flows in Heterogeneous Porous Media
Geothermie Kongress, Karlsruhe, October

Engelhardt, Lilli; Bitsch, Gerd; Schindler, Christian
Online Condition Monitoring based on Real-Time System Simulation
1st Commercial Vehicle Technology Symposium, Kaiserslautern, March

Engelhardt, Lilli; Burger, Michael; Bitsch, Gerd
Real-Time Simulation of Multibody Systems for On-Board Applications
The First Joint International Conference on Multibody System Dynamics, Lappeenranta (SF), May

Erlwein, Christina; Müller, Marlene
Modelling of alternative investments: a regime-switching regression model for hedge funds
Statistische Woche, Nürnberg, September

Erlwein, Chrsitina; Mamon, Rogemar; Davison, Matt
HMM-based investment strategies for asset allocation
24th European Conference on Operational Research, Lissabon (P), July

Ettrich, Norman; Merten, Dirk; Foss, Stig-Kyrre; Osen, Are
Seismische Wahre-Amplituden Tiefen-Migration im Winkelbereich
Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bochum, March

Ewe, Hendrik
Profit Sharing Amongst Collaborating Freight Carriers
24th European Conference on Operational Research, Lissabon (P), July

Gaisser, Andrea E.; Trinkaus, Hans L.
Software-assisted analysis of cancer information and counseling by telephone: SACA
International Conference on Communication in Healthcare, Verona (I), September

Glatt, Erik; Becker, Jürgen; Rief, Stefan; Cheng, Liping; Wiegmann, Andreas
Material Models and Property Prediction based on CT-Scans
3D-IMS, Hourtin (F), September

Hansen, Neele
Modifying timetables for integrated schedules
Lissabon (P), July

Hauser, Matthias
Design of robust electronic circuits for yield optimization
The XIth International Workshop on Symbolic and Numerical Methods, Modeling and Applications to Circuit Design (SM2ACD), Tunis-Gammarth (TN), October

Herkt, Sabrina; Dreßler, Klaus; Pinnau, René
Nonlinear Model Reduction for Rubber Components in Vehicle Engineering
Model Reduction for Complex Dynamical Systems, Berlin, December

Herkt, Sabrina; Öngün Yekta; Dreßler Klaus
Erstellung und Anwendung von FEM-Reifenmodellen in der Fahrzeugsimulation
Deutsche Simulia Konferenz, Heidelberg

Herkt, Sabrina; von Holst, Christian
Parameterization of MBS Tire Models for Tractors Based on FEM Simulations
1st Fraunhofer Conference on Multiphysics, Bonn, June

Hermanns, Oliver; Stephan, Thomas; Lang, Holger; Linn, Joachim
Optimale Pfadplanung und interaktive Simulation flexibler Kabel und Schläuche
6. ATZproduktion Fachtagung Zukunft Automobilmontage, Wolfsburg, September

Hietel, Dietmar
Improvement of Spinning Processes using Modelling and Simulation
PET/PA & Intermediates Conference, Frankfurt, June

Hietel, Dietmar
Modellierung, Simulation und Optimierung für industrielle Anwendungen
IAF-Kolloquium, Ulm, March

Hietel, Dietmar
Simulation als Schlüssel für neue Materialien in Faserprozessen
DGM-Strategieworkshop Modellierung und Simulation, Aachen, November

Hoeft, Frank; Stephan, Thomas
Simulation flexibler Bauteile in der Fahrzeugentwicklung
AUDI CA-Forum, Ingolstadt

Horbenko, Nataliya; Ruckdeschel, Peter
Robust Estimation of Operational Risk
4th European Risk Conference Perspectives in risk management: Accounting, Governance and Internal Control, Nottingham (GB), September; 14th International Congress on Insurance: Mathematics and Economics,Toronto (CDN), June

Horbenko, Natalyia; Ruckdeschel, Peter
Robustness for GPD: Parameterizations, Algorithms, Diagnostics
International Conference on Robust Statistics Prag (CZ), July

Iliev, Oleg
Flow and material simulation for industrial purposes
Nippon Steel, Tokyo (J), February

Iliev, Oleg
Multiscale flow and material simulation of industrial problems
Mathematics in Industry, Int. Conf., Sofia (BG), July

Iliev, Oleg
On certain industrial multiscale problems with separable and unseparable scales
Multiscale Problems in Science and Technology, Dubrovnik (BG), May

Iliev, Oleg
On multiscale flow and material simulations
Goethe Zentrum for Sci. Computing, Frankfurt University, October

Iliev, Oleg, Schindelin, Andreas und Wiegmann, Andreas
Computer aided development of hydraulic filter elements – From theory to patent and products
1. Commercial Vehicle Technology Symposium Kaiserslautern, March

Iliev, Oleg; Andrae, Heiko, Kabel, Matthias, Lakdawala, Zahra, Steiner, Konrad
Multiscale Flow and Material Simulation
Seminar Appl. Math Modelling & Optimization AMMO, Univ. of Appl. Sci. Bielefeld, April; Felix Klein Summer School, Kaiserslautern, September

Iliev, Oleg; Bartkowski, Konrad; Latz, Arnulf; Zausch, Jochen
Modeling and Simulation of species and charge transport in Li-Ion Batteries
Numerical Methods and Applications: 7th International Conference, NMA, Borovets (BG), August

Iliev, Oleg; Lakdawala, Zahra; Dedering, Michael;Starikovicius, Vadimas
On modeling and simulation of filtration efficiency tests
Annual Meeting of American Filtration Society, San Antonio (USA), March

Iliev, Oleg; Lazarov, Raytcho; Willems, Joerg
Variational Multiscale Method for Stokes-Brinkman problem
Faculty of Mathematics, Tokyo University (J), February

Ilyasov, Maxim
Seismic Data Processing in Terms of Locally Supported Wavelets
DAYS on DIFFRACTION, St. Petersburg (RUS), June

Ilyasov, Maxim; Möhringer, Sandra
Seismische Untergrundbilder und Gravimetrie
Geothermiekongress, Karlsruhe, November

Jegorovs, Jevgenijs
On the extension of the Wave Based Method
Days on Difractions, St. Petersburg (RUS), June

Kabel, Matthias; Andrä, Heiko; Iliev, Oleg; Stüben, Klaus
AMG and Micromechanics
European Multi-Grid Conference EMG, Isola d'Ischia (I), September

Kirsch, Ralf; Iliev, Oleg; Lakdawala, Zahra; Andrä, Heiko; Kabel, Matthias; Dedering, Michael
CFD and efficiency tests simulations supporting filter element designs
European Conference on Fluid Particle Separation, Lyon (F), October

Korn, Ralf
Interest rate models – products, and their valuation in theory and industry
Fraunhofer-OptiRisk-Workshop, London (GB), September

Korn, Ralf
Monte Carlo Methods in Finance: Basic Methods and Recent Advances
Fraunhofer-OptiRisk-Workshop, Brunel University London (GB), November

Korn, Ralf
Portfolio Optimization and Transaction Costs in Action
Oberseminar Finanzmathematik TU München, July

Korn, Ralf
Recent Advances in Option Pricing via Binomial Trees
Dublin City University (IRL), March und Workshop on Numerical Methods in Finance, Fields Institute Toronto (CDN), March

Korn, Ralf
Transaction Costs: A Practical Approach
ITWM-Evry-Workshop, March

Korn, Ralf
Transaction Costs: Theory and Practical Applications
Imperial College London (GB), April

Korn, Ralf
Weak Extrapolation Monte Carlo Methods
Univ. Cambridge (GB), December

Korn, Ralf
Zinsmodelle, Zinsprodukte und ihre Bewertung in Theorie und Praxis
Inhouse-Workshop bei der R+V, Wiesbaden, September

Korn, Ralf
Zinsmodellierung und Bewertung von Zinsprodukten in der Praxis
ITWM-Praktiker-Workshop, Kaiserslautern, June

Krüger, Jens
The Green Wave Project
Universität Mannheim, December

Krüger, Jens
The Green Wave Project – A semi custom design for RTM and beyond
SEG, Denver (USA), October

Küfer, Karl-Heinz
Decision support systems based on multicriteria optimization
Jyväskylä (SF), September

Küfer, Karl-Heinz
Patientenindividuelle medizinische Therapieplanung
Kaiserslautern, June

Küfer, Karl-Heinz; Klein, Peter; Süss, Philipp
Multicriteria Optimization – integration of simulation and optimization
Schwalbach, April

Küfer, Karl-Heinz; Monz, Michael
Fraunhofer ITWM and radiotherapy planning
Stockholm, February

Küfer, Karl-Heinz; Welke, Richard; Hasse, Hans
Entscheidungsunterstützung in der Chemieanlagenplanung
Ludwigshafen, May

Kühn, Martin
Parallelization of an Edge- and Coherence-Enhancing Anisotropic Diffusion Filter with a Distributed Memory Approach based on the Fraunhofer Virtual Machine
CiHPC Status Conference of the Gauß-Allianz, Schwetzingen, June

Kuhnert, Jörg
Finite Pointset Method (FPM): a Purely Meshfree Simulation Tool for Airbag deployment
CAE Grand Challenge, Hanau, March

Kuhnert, Jörg
Finite Pointset Method (FPM): Meshfree numerical solution of Population Balance Equations
ECMI 2010, Wuppertal, July

Kuhnert, Jörg; Tramecon, Alain
Méthode sans Mayllage FPM (Finite Points Method) et applications aux problématiques d'interaction fluide structure
séminaire NAFEMS Méthodes Avancées de Simulation Numérique, Paris (F), June

Lagemann, Christian; Hüper, Knut; Helmke, Uwe; Lang, Patrick
LQG Balancing: Intertwining Balancing and Sign Iterations
49th IEEE Conference on Decision and Control, Atlanta (USA), December

Lang, Patrick
From Data Analysis to Biomarker Identification
Workshop Mathematik für Personalisierte Medizin, Fraunhofer-Zentrum, Kaiserslautern, June

Lang, Patrick
Modellreduktion für Design und Analyse elektronischer Schaltungen

Mathematisch-technisches Kolloquium, Fachhochschule Koblenz / RheinAhrCampus Remagen, June

Latz, Arnulf
Modellierung und Simulation komplexer fließfähiger Stoffe für industrielle Anwendungen: Schüttgüter, Fasersuspensionen und Elektrolyte
Institut für Verfahrenstechnik Kaiserslautern, December

Latz, Arnulf; Niedziela, Dariusz; Strautins, Uldis; Hosdez, Valerie; Kech, Armin
Improved Fiber Orientation modeling in injection molding of short fiber reinforced thermoplastics: Simulation and Experiment
1st International Conference Multiphysics Simulation, Bonn, June

Latz, Arnulf; Zausch, Jochen
Electro-thermal Modeling and Simulation of Li-Ion Batteries
ISE Nizza (F), September

Latz, Arnulf; Zausch, Jochen
Mesoscopic Modeling and Simulation of charge and ion transport in Li-Ion Battery cells
Dechema Materials and Energy, Karlsruhe, July

Leithäuser, Christian
Supremum Norm Shape Optimization
Summer School: Optimal Control of Partial Differential Equations, Cortona (I), July

Lemke, Tatjana
Inference for Autoregressive Time Series with Asymmetric Alpha-Stable Innovations
University of Cambridge (GB), December

Iiev, Oleg; Lakdawala, Zahra; Rief, Stefan; Schmidt, Kilian; Steiner, Konrad; Wiegmann, Andreas
Multiskalensimulation von Filtermedien und Filtersystemen
ITWM Kuratoriumsitzung, Kaiserslautern, February

Lorenz, Stefan
Aspekte des 2-Faktor-Hull-White Modells
Inhouse-Workshop R+V, Wiesbaden, October

Maasland, Mark
Oberflächeninspektion in Kombination mit weiteren Messverfahren
Fraunhofer Vision Seminar Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung, Karlsruhe, December

Marheineke, Nicole; Marburger, Jan
Optimization Strategies with Mesh-less Methods for PDEs
ECCM 2010, Paris (F), May

Marheineke, Nicole; Wegener, Raimund
Stochastic PDAE-Model and Associated Monte-Carlo Simulations for Elastic Threads in Turbulent Flows
ECMI 2010, Wuppertal, July

Michel, Dominik
Mit Gewinn Sparen – Energie Effizient Nutzen
IHK-Zetis, Green IT, Landau

Michel, Dominik; Amirbekyan, Abel; Ettrich, Norman; Merten, Dirk; Osen, Are; Foss, Stig-Kyrre
Seismische Beam-Migration zur schnellen Erzeugung von strukturellen Untergrundabbildungen
Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bochum, March

Monz, Michael
Mehrkriterielle IMRT-Planung unter Berücksichtigung der Einstrahlrichtungen
Freiburg, October

Nam, Alexander; Orlik, Julia
Simulation of the Effective Properties of Heterogeneous Textile Layer by Asymptotic Approach
GAMM-Jahrestagung: Multiscales and Homogenization, Karlsruhe, March

Neundorf, Alexander; Götz, Tobias
Pre-Stack PRO – A High-Performance Seismic Data Processing Solution
CiHPC Status Conference of the Gauß-Allianz, June

Neunzert, Helmut
Joseph von Fraunhofer
Inner Wheel, Kaiserslautern, June

Neunzert, Helmut
Kinetic Schemes in Fluid Dynamics
Jerusalem (IL), April

Neunzert, Helmut
Mathematical Modeling of Industrial Problems
Drukininkai (LV), May

Neunzert, Helmut
Models for industrial problems: How to find and how to solve them – in industry and education
Bedlewo (PL), October

Neunzert, Helmut
Wieviel Mathematik steckt in einem MP3-Player?
Maynz, November

Nickel, Stefan
A Multi-stage Stochastic Supply Chain Network Design Problem with Financial Decisions and risk
Austin (USA)

Nickel, Stefan
Location-Problems in Supply Chain Management
Montreal (CDN)

Nickel, Stefan
Multiperiod Location Problems for Supply Network Planning
Dagstuhl

Nowak, Uwe
Rotation Optimization of Connected Circles
Aveiro (P), July

OberMayer, Harald
On Moving-Least Squares Based Flow Analysis
2nd IRTG Kick-Off Meeting, Bodega Bay (USA), March

OberMayer, Harald
Time-Surface Maps
VisWeek Workshop: Foundations of Topological Analysis, Salt Lake City (USA), October

Obermayr, Martin; Öngün, Yekta; Dreßler, Klaus
Simulation of soil behaviour in virtual product development
1st Commercial Vehicle Technology Symposium, Kaiserslautern, March

Obermayr, Martin; Öngün, Yekta; Dreßler, Klaus
Simulation of Soil-Machine Interaction in Agricultural Engineering
VDI-Tagung Landtechnik, Braunschweig, October

Olawsky, Ferdinand
Numerical Treatment of Fiber-Fiber and Fiber-Obstacle Contacts in Technical Textile Manufacturing
ECMI 2010, Wuppertal, July

Pfreundt, Franz-Josef
Die Zukunft Performance-kritischer IT-Infrastrukturen
CxO Dialog Dynamic IT, Berlin, April

Pfreundt, Franz-Josef
FhgFS – Entwicklungen und Erfahrungen
ZKI-Arbeitskreis Supercomputing Universität Hamburg, March

Pfreundt, Franz-Josef
FVM – the Fraunhofer parallel Programming Modell for todays and future HPC Systems
T-Systems Solutions for Research GmbH, HPCN-Workshop 2010 Braunschweig, May

Pfreundt, Franz-Josef
HPC Technologies for Interactive Processing Basic HPC requirements and tools for Prestack Interpretation
EAGE, Barcelona (E), June

Pfreundt, Franz-Josef
mySmartGrid – ein Projekt des Fraunhofer ITWM
Tagung der Betriebsleiter und Betriebsingenieure Stromversorgung der Pfalzenergie, Speyer, March

Pfreundt, Franz-Josef
SDPA – How to program large scale parallel geophysics applications?
Stanford University, (USA), October

Pfreundt, Franz-Josef
Smart Grids – The future of electrical power generation and consumption
S.A.M.E., Ramstein, January

Pfreundt, Franz-Josef
The Global Address space programming interface GPI and our approach to autoparallelization
Lawrence Berkeley National Laboratory (USA), October

Pfreundt, Franz-Josef; Rahn, Mirko
SDPA – A Seismic Processing Architecture
SEG, Denver (USA), October

Rahn, Mirko
FVM instead of MPI
CiHPC Status Conference of the Gauß-Allianz, June

Rahn, Mirko
GPI – Global Address Space Programming Interface
SEPARS, Stuttgart, December

Rauhut, Markus
Typischer Aufbau eines Online-Oberflächeninspektionssystems
Fraunhofer Vision Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung«, Karlsruhe, December

Rauhut, Markus; Spies, Martin; Taeubner, Kai
Detektion und Auffindwahrscheinlichkeit von Oberflächenfehlern in Metallen mittels optischer Inspektionsverfahren
DGZfP-Jahrestagung, Erfurt, May und VDI/VDE Forum Bildverarbeitung, Regensburg, December

Rauhut, Markus; Spies, Martin; Taeubner, Kai
Probability of Detection of Surface Defects in Metals Using Optical Inspection Techniques
Review of Progress in Quantitative NDE 2010, San Diego (USA), July

Redenbach, Thomas; Spies, Martin; Wagner, Björn; Wirjadi, Oliver
X-Ray and Ultrasonic Imaging of Structural Materials for Aerospace Applications
International Symposium on NDT in Aerospace, Hamburg, November

Rieder, Hans; Spies, Martin; Dillhöfer, Alexander; Kapteijn, Louwrens; van Kooij, Adri; Leever, Sylvia; Junglewitz, Andreas
Schweißen und Prüfen statt Verschrotten – Zerstörungsfreie sicherheitstechnische Bewertung der Reparatur eines Schiffspropellers
DGZfP-Jahrestagung, Erfurt, May

Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Graff, Alfred; Orth, Thomas; Kersting, Thomas
SAFT- und TOFD-Auswertung für die Ultraschall-Schweißnahtprüfung von längsnahtgeschweißten Großrohren
DGZfP-Jahrestagung, Erfurt, May

Ronald Rösch
Innovation durch Algorithmik
Bildverarbeitung – Quo Vadis? – Kolloquium anlässlich der Verabschiedung von Dr. Norbert Bauer, Erlangen, March

Rösch, Ronald
Fehlerdetektion in texturierten Oberflächen im praktischen Einsatz
Fraunhofer Vision-Technologietag 2010, Stuttgart, September

Ruckdeschel, Peter
Sektionsleitung »Statistik dynamischer Prozesse«
Statistische Woche in Nürnberg (Jahrestagung Deutsche Statistische Gesellschaft), September

Ruckdeschel, Peter; Horbenko, Nataliya
Breakdown point properties for estimators in Generalized Pareto Models
DAGStat2010, Statistik unter einem Dach, Dortmund, March und Stochastiktage, (Fachgruppe Stochastik der DMV) Leipzig, April

Ruckdeschel, Peter; Horbenko, Nataliya
Robust Estimation in Generalized Pareto Distributions
ICORS 2010, Prag, June

Ruckdeschel, Peter; Korn, Ralf; Kohl, Matthias; Spangl, Bernhard
Robust Risk Estimation
Projektvorstellung Extreme Events: Modeling, Analysis, and Prediction, VW Stiftung, Hannover, October

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Robustifications of the EM Algorithm for State Space Models
Statistische Woche Nürnberg, September und 3rd international Conference of the ERCIM, Workgroup Computing and Statistics, London (GB), December

Sarishvili, Alex
Optimale Versuchsplanung (DOE) in ausgewählten Problemszenarien
Workshop: Data-Mining in der verfahrenstechnischen Industrie, Kaiserslautern, June

Sarishvili, Alex
Probleme bei der Anwendung der klassischen optimalen Versuchsplanung und mögliche Lösungsansätze
9. Kongress: Design of Experiments, Kassel, November

Schäfer, Matthias
STRING – Intuitive Animation von Gewässerströmungen
9. SPRING Conference, Witten, November

Scherrer, Alexander
Entscheidungsunterstützung in der virtuellen Produkt- und Prozessentwicklung
Rapperswil (CH), April

Scherrer, Alexander
Schlüsselqualifikation Mathematik
Landstuhl, June

Schladitz, Katja
Analyse von 3D-Bildern der Mikrostruktur von Werkstoffen
Seminar des Instituts für Technische Mechanik, KIT, Karlsruhe, May

Schladitz, Katja
Mikrostrukturanalyse anhand von 3D-Bilddaten
6. Thüringer Geometrietag, FSU, Jena, December

Schladitz, Katja
The curse of discretization - lessons from image analysis
Felix-Klein-Sommerschule, Kaiserslautern, September

Schladitz, Katja
Quantitative analysis of materials structures based on 3D image data
Microscopy and Microanalysis 2010, Portland (USA), August

Schladitz, Katja
Partikelcharakterisierung in 3d
Industrielle Computertomografie, FHOÖ, Wels (A), September

Schmidt, Oliver
Coupled symbolic-numerical model reduction using the hierarchical structure of nonlinear electrical circuits
Model Reduction for Complex Dynamical Systems, Berlin, December

Schmidt, Oliver
Structure-exploiting symbolic-numerical model reduction of nonlinear electrical circuits
16th European Conference on Mathematics for Industry, Wuppertal, July

Schröder, Michael
Decision support systems in supply chain management
Worms, November

Schröder, Michael
Der Software-Cluster – Regionale Stärke durch Innovation
Kaiserslautern, November

Schröder, Michael
Forschung im BMBF-Spitzencluster »Softwareinnovationen für das digitale Unternehmen«
Kaiserslautern, November

Schröder, Michael
Opti-TRANS – optimierungsgestützte Transportdisposition im Krankenhaus
Cottbus, February und Pirmasens, May

Schwientek, Jan
A bi-level method for solving GSIPs using entropic regularization
Karlsruhe, September

Schwientek, Jan
Multi-Body Design Centering
Erice (I), July

Siedow, Norbert; Hering-Bertram, Martin; Tse, Oliver; Wegener, Raimund; Plontke, Stefan
Simulation der Pharmakokinetik im Innenohr; Vorhersage der Aufnahme und Verteilung von Wirkstoffen mittels Computersimulation
BIOTECHNICA, Hannover, October

Siedow, Norbert
Inverse Problems
Felix-Klein-Sommerschule, Kaiserslautern, September

Smaga, Marek; Eifler, Dietmar; Zangmeister, Tobias; Andrä, Heiko; Zhang, Xingxing
Modeling and experimental investigation of microstructure, residual stresses and monotonic deformation behavior of aluminum matrix composites
5th Conference on Multiscale Materials Modeling, Freiburg, October

Speckert, Michael; Dreßler, Klaus; Ruf, Nikolaus; Müller, Roland; Weber, Christof
Customer Usage Profiles, Strength Requirements and Test Schedules in Truck Engineering
1st Commercial Vehicle Technology Symposium, Kaiserslautern

Spies, Martin
Model-Based Optimization of Carbon-Fiber Component Ultrasonic Inspections
International Symposium on NDT in Aerospace, Hamburg, November

Spies, Martin
Model-Based Simulation for Imaging and Evaluation of Materials Properties and Irregularities
INM-Kolloquium, Institut für Neue Materialien, Saarbrücken, December

Spies, Martin
Ultraschall-Imaging – Simulationsgestützte Inspektion komplexer Bauteile
Ausschuss Industrie des Deutschen Kupferinstituts, Düsseldorf, March

Spies, Martin; Redenbach, Thomas; Rieder, Hans; Herkt, Sabrina
Bestimmung von Strukturmerkmalen und Materialeigenschaften von stahlfaserverstärkten Reifen
DGZfP-Jahrestagung, Erfurt, May

Spies, Martin; Rieder, Hans
SAFT Ultrasonic Imaging and Sizing of Stress Corrosion Cracks in the Heat-Affected Zone of Welded Austenitic Pressurized Components
8th International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurised Components, Berlin, September

Spies, Martin; Rieder, Hans
Der Einfluss der Schallschwächung in Guss- und Verbundwerkstoffen auf die Schallfelder von Standard- und Gruppenstrahler-Prüfköpfen
DGZfP-Jahrestagung, Erfurt, May

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
On-site Evaluation of Large Components Using SAFT and TOFD Ultrasonic Imaging
Review of Progress in Quantitative NDE 2010, San Diego (USA), July

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
Simulation-Based Ultrasonic Testing and Imaging of Welds and Components
CIVA2012 UT Workshop, Commissariat à l'Energie Atomique, Saclay (F), October

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
Verbesserung der Fehlerauffindwahrscheinlichkeit mit SAFT bei der Ultraschallprüfung von schwer prüfbaren Werkstoffen
DGZfP-Jahrestagung, Erfurt, May

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
Zerstörungsfreie Ultraschallprüfung zur Bewertung der Reparatur eines 100 Tonnen schweren Schiffspropellers
HochschulKupferSymposium HKS 2010, Saarbrücken, November

Steiner, Konrad
Flow problems in industrial porous media
Interpore, Texas (USA), March

Steiner, Konrad
Multiskalenintegrierende Struktureigenschaftssimulation der Faserorientierung für faserverstärkte Kunststoffe im Automobil- und Flugzeugbau
Fraunhofer Netzwert, München, December

Steiner, Konrad
Simulation techniques for the design process of fibrous materials
Fibres & Fabrics – P&G, Schwalbach, November

Stephan, Thomas; Hoeft, Frank; Hermanns, Oliver
Eine neue Methode zur vergleichenden örtlichen Beanspruchungsanalyse für Kabel und Schläuche
SIMVEC-Berechnung und Simulation im Fahrzeugbau, Baden-Baden

Stephani, Henrike
Hyperspectral Terahertz Image Analysis – extracting chemical content with feature reduction and hierarchical clustering
Machine Vision Fachbereich der Universität Bremen, October

Süss, Philipp
Imrt Solver – roles & attributes
Heidelberg, October

Trinkaus, Hans L.
Information Retrieval
Control Theory, Seminar, TU Kaiserslautern, January

Trinkaus, Hans L.
knowCube for Exploring Decision Spaces: Sandwiches, Foams and Drugs
International Conference on Knowledge Management and Knowledge Technologies 2010, Graz (A), September

Venturi, Alberto
Symbolic model order reduction for circuits with parameter variations
The 16th European Conference on Mathematics for Industry (ECMI 2010), Wuppertal, July

Wagner, Andreas
Populäre Short Rate-Modelle und ihre Eigenschaften
Inhouse-Workshop R+V, Wiesbaden, October

Weibel, Thomas; Daul, Christian; Wolf, D.; Rösch, Ronald, Ben-Hamadou, A.
Endoscopic bladder image registration using sparse graph cuts
ICIP 2010, Hongkong, September

Weigel, Nicolas; Weihe, Stefan; Speckert, Michael; Feth, Sascha
New Approaches for Efficient Statistical Fatigue Validation
1st Commercial Vehicle Technology Symposium, Kaiserslautern

Welke, Richard; Küfer, Karl-Heinz
Entscheidungsunterstützung in der Chemieanlagenplanung
Kaiserslautern und Aachen, March

Wenzel, Jörg
Bewertung exotischer Zinsprodukte im LIBOR model
Inhouse-Workshop R+V, Wiesbaden, October

Wenzel, Jörg
Generic interest rate pricing in a two-factor Hull-White model
Fraunhofer-OptiRisk Workshop London (GB), September

Wenzel, Jörg
Scenario generation for a Swedish pension fund
Fraunhofer-OptiRisk Workshop London (GB), September

Wiegmann, Andreas
Microstructure Simulation and Virtual Material Design
1st International Conference Multiphysics Simulation, Bonn, June

Wiegmann, Andreas; Iliev, Oleg
Modelling and prediction of percolation and conductivity properties of CNT-polymer compounds
3rd International Workshop: 3D Imaging, Analysis, Modeling and Simulation of Macroscopic Properties, Fontainebleau (F), April

Wiegmann, Andreas; Cheng, Liping; Rief, Stefan
Filtration simulation on the nano scale – the influence of slip flow
European Conference On Fluid-Particle Separation, Lyon (F)

Wiegmann, Andreas; Cheng, Liping; Rief, Stefan
Simulation of nano fibers and filter efficiency
American Filtration & Separations Annual Conference, San Antonio (Texas, USA), March

Winterfeld, Anton
Mehrkriterielle Optimierung von Warmwalzprozessen in der Stahlindustrie
Bremen, February

TEACHING ACTIVITIES

Wirjadi, Oliver
3D-Characterization and Modeling of Composite Materials
Workshop Image Processing: Trends and Applications, Kaiserslautern, March

Wirjadi, Oliver
3D-Characterization of Fibre-Reinforced Composites
GE High Resolution X-ray CT Symposium, Dresden, August

Wirjadi, Oliver
3D-Image Analysis for Fiber-Reinforced Composites
Composites Forum 2010, Essen, September

Wirjadi, Oliver
Geometrische 3D-Porenraumcharakterisierung für Materialien und Verbundstoffe
Fraunhofer Vision-Technologietag 2010, Stuttgart, September

Wirjadi, Oliver
Gradient-based algorithms for computing the volume-weighted fiber direction distribution
IV European Congress on Computational Mechanics, Paris (F), May

Wirjadi, Oliver
Volume Image Segmentation and Analysis
ESRF Seminar, Grenoble (F), March

Wirsen, Andreas; Mohring, Jan
Methods for H2 optimal actuator placement and controller design for high dimensional parametric structures
IV European Conference on Computational Analysis, Paris (F), May

Witschas, Michael; Hietel, Dietmar
Optimisation of a Staple Fibre Spinning Process by Simulations
49th Dornbirn Man-Made Fibers Congress, Dornbirn (A), September

Zemitis, Aivars
Some Insights into Multiscale Simulations and Industrial Applications
15th International Conference Mathematical Modelling and Analysis, Druskininkai (LT), May

Zemitis, Aivars; Iliev, Oleg; Lakdawala, Zahra; Starikovicius, Vadimas
On a Subgrid Approach for Simulating Industrial Filtration Processes
Fifth European Conference on Computaional Fluid Dynamics, Lissabon (P), June

Andrä, Heiko
Einführung in die Boundary-Element-Methode
University of Kaiserslautern, Sommer term 2010

Andrä, Heiko
Festigkeitslehre
Cooperative State University Baden-Wuerttemberg Mannheim, Winter term 2010/11

Bitsch, Gerd
Mechatronische Systeme
University of Applied Sciences Kaiserslautern, Winter term 2010/11

Erlwein, Christina
Markov Switching Models and their applications in Finance
University of Kaiserslautern, Winter term 2010/11

Iliev, Oleg
PDE based multiscale problems and numerical approaches for their solution
University of Kaiserslautern, Winter term 2009/10

Klar, Axel
Professur für Technomathematik
University of Kaiserslautern, Dept. of Mathematics

Knaf, Hagen
Unüberwachtes Lernen – eine Einführung
University of Kaiserslautern, Sommer term 2010

Korn, Ralf
Professur für Stochastsische Steuerung und Finanzmathematik
University of Kaiserslautern, Dept. of Mathematics

Küfer, Karl-Heinz
Theorie von Scheduling-Problemen
University of Kaiserslautern, Sommer term 2010

Küfer, Karl-Heinz; Schröder, Michael
Seminar zur Optimierung für industrielle Anwendungen
University of Kaiserslautern, Sommer and Winter term 2010/11

Küfer, Karl-Heinz
Probability and Algorithms
University of Kaiserslautern, Winter term 2010/11

Nickel, Stefan
Professur für Diskrete Optimierung und Logistik
KIT Karlsruhe, Institute for Operations Research

Orlik, Julia
Homogenisierung
University of Kaiserslautern, Winter term 2010/11

Prätzel-Wolters, Dieter
Professur für Technomathematik
University of Kaiserslautern, Dept. of Mathematics

Rieder, Hans
Simulation and Hardware Implementations of Digital Algorithms and Systems (Part: Implementations of Signal Processing Algorithms based on embedded DSP Technology)
University of Applied Sciences Saarbrücken, Labratory for high-frequency engineering, Winter term 2010/11

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Devroye, Luc; Karasozen, Bulent; Kohler, Michael; Korn, Ralf
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Maleshkov, Dimo
The Interceder: A Communication Framework to Monitor and Steer
Diploma thesis, University of Kaiserslautern, Dept. of Computer Sciences

Meier, Stefan
Multigrid methods for efficient image enhancement
Diploma thesis, University of Applied Sciences Darmstadt, Dept. of Mathematics and Natural Science

Miltz, Michael
Thermische Analyse von gesinterten und geklebten Hohlkörperstrukturen mit Hilfe von GeoDict
Bachelor thesis, University of Applied Sciences Aalen, Dept. of Mechanical Engineering

Peters, Stefanie
Automatischer Entwurf und Autokonfiguration von Bildverarbeitungssystemen für die industrielle Oberflächeninspektion
Doctoral thesis, University of Kaiserslautern, Dept. of Electrical and Computer Engineering

Ries, Marc
Indextracking
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

PARTICIPATION ON FAIRS AND CONFERENCES

Rinder, Christian
Multikriterielle Optimierung der Wärmeleitung in beschichteten Aluminiumstrukturen
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Ruckdeschel, Peter
Optimally Robust Estimation and Filtering: Concepts, Enhancements and Implementations
Post doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Sautner, Philipp
Mehrperiodische Optimierungsansätze zur Vertriebs- und Wahlkreisplanung
Bachelor thesis, KIT Karlsruhe, Economics

Schmidt, Oliver
Structure-Exploiting Coupled Symbolic-Numerical Model Reduction For Electrical Networks
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Schnebele, Johannes
Numerical and Statistical Analysis of the Conveyor Belts' Impact on Fiber Lay Down Processes
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Schröder, Simon
Surface Reconstruction from 3D Point Clouds with Associated Image Correspondences
Diploma thesis, University of Kaiserslautern, Dept. of Computer Sciences

Schüle, Ingmar
RLT Approaches to QSAPs - Applied to Timetable Synchronization in Public Transport
Doctoral thesis, University of Kaiserslautern, Dept. of Mathematics

Tombrink, Tobias
Aggregation Techniques for Large-Scale Assignment Problems in Marketing Models
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

Ursachi, Irina
The Cheyette Model in Theory and Practise
Master thesis, University of Kaiserslautern, Dept. of Mathematics

Walter, Martin
Analyse, Optimierung und Implementierung der Distributionsstruktur eines Nutzfahrzeugherstellers dargestellt am Beispiel der innereuropäischen LKW-Chassisüberführung der MAN Nutzfahrzeuge
Diploma thesis, KIT Karlsruhe, Economics

Zanter, Christian
Untersuchung zur Ermittlung von Planier- und Schneidkräften im Erdbau
Diploma thesis, University of Kaiserslautern, Dept. of Civil Engineering

Zürker, Moritz
Arbitragefreie Modellierung von Volatilitätsflächen
Diploma thesis, University of Kaiserslautern, Dept. of Mathematics

3D IMS 2010, 2nd Conference on 3D-Imaging of Materials and Systems 2010
Hourtin (F), September

American Filtration and Separation Society – Annual Conference 2010
San Antonio (USA), March

Analog 2010: 11. ITG / GMM - Fachtagung
Erfurt, March, Exhibitor and lectures

6. ATZproduktion Fachtagung - Zukunft Automobilmontage
Wolfsburg, September, Exhibitor

42. Bildverarbeitungsforum »Lernende Bildverarbeitung – Neuroinformatische und statistische Ansätze«
Frankfurt, March

43. Bildverarbeitungsforum »Hardwarearchitekturen für die Bildverarbeitung«
Herrenberg, July

44. Bildverarbeitungsforum »Bildverarbeitung und Computergrafik«
Saarbrücken, October

CARNOT 2010 – Forschungsmesse
Lyon (F), May, Exhibitor

1. Commercial Vehicle Technology Symposium Kaiserslautern
Kaiserslautern, March, Exhibitor, Lectures, Co-organizer

Composite2010 – 23rd International Workshop Research in Mechanics of Composites
Bad Herrenalb, November, Vortrag

Composites Europe 2010
Essen, September, Exhibitor

1st Conference on Multiphysics Simulation
Bonn, June

CONTROL 2010 – Internationale Fachmesse für Qualitätsicherung
Stuttgart, May, Exhibitor

CVC-Jahrestagung 2010: Commercial Vehicle Industry – CO_2-optimiert und energieeffizient
Mannheim, November, Exhibitor and lectures

DATE 10 – Design, Automation & Test in Europe
Dresden, March, Exhibitor

DVM-Arbeitskreis Betriebsfestigkeit
München, October, Exhibitor

EAGE 2010 – 72th European Association of Geoscientists and Engineers Conference and Exhibition
Barcelona (E), June, Exhibitor and lectures

ECMI – 16th European Conference on Mathematics for Industry
Wuppertal, July, Lectures

European Congress on Computational Mechanics (ECCM IV)
Paris (F), May, Lectures

Fachtagung für Industrielle Computertomografie
Wels (A), September, Lecture

FILTREX 2010
Köln, October, Exhibitor and lectures

17th Forecasting Financial Markets Conference 2010
Hannover, May, Exhibitor and lectures

FPS2010 – European Conference On Fluid-Particle Separation
Lyon (F), October

Fraunhofer Vision Seminar: Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung
Karlsruhe, December, Exhibitor and lectures

Fraunhofer Vision-Technologietag 2010
Stuttgart, September, Exhibitor and lectures

3rd Fraunhofer-Carnot Workshop: 3D Imaging, Analysis, Modelling and Simulation of Macroscopic Properties
Fontainebleau (F), April, Lectures, Poster, Co-organizer

GE High Resolution X-ray CT Symposium
Dresden, August, Lecture

AWARDS AND PRIZES

Graduate School "Physics and Mechanics of Random Media"
Paris (F), November

Hannover Messe – Digital Factory
Hannover, April, Exhibitor

HochschulKupferSymposium HKS 2010
Saarbrücken, November, Poster

25. Hofer Vliesstofftage
Hof, November, Exhibitor and lectures

IAA Nutzfahrzeuge 2010
Hannover, September, Exhibitor

ICIP 2010
Hong Kong (HK), September, Lecture

IFAT 2010 – 16. Internationale Fachmesse für Wasser, Abwasser, Abfall und Recycling
München, September, Exhibitor

IMSD–First Joint International Conference on Multibody System Dynamics
Lappeenranta (FI), May

InnoTrans 2010 - Internationale Fachmesse für Verkehrstechnik, Innovative Komponenten, Fahrzeuge, Systeme
Berlin, September, Exhibitor

1. Int. Definiens Symposium
Madrid (S), October

20th Interantional Conference on Pattern Recognition (ICPR)
Istanbul (TR), August, Poster

INTERFILTRA 2010
Lyon (F), October, Exhibitor and lectures

8th International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurised Components
Berlin, September, Lectures

International Symposium on NDT in Aerospace
Hamburg, November, Lecture, Poster

4th International Workshop on Terahertz Technology
Kaiserslautern, April, Poster

68. Internationale Tagung Landtechnik
Braunschweig, October

ISC'10 – International Supercomputing Conference
Hamburg, May, Exhibitor and lectures

it&business – Fachmesse für Software, Infrastruktur und IT-Services
Stuttgart, October, Exhibitor

IWAP – 5th International Workshop on Applied Probability
Madrid (S), July, Lectures

Jahrestagung 2010 der Deutschen Gesellschaft für Zerstörungsfreie Prüfung e.V. (DGZfP)
Erfurt, May, Poster and lectures

33ème journée ISS France
Paris (F), February, Lecture

MathFinance Conference
Frankfurt, March

NAFEMS
Wiesbaden, April

PharmaForum 2010
Maynz, November, Exhibitor

POWTECH 2010 – Internationale Fachmesse für Mechanische Verfahrenstechnik und Analytik
Nürnberg, April, Exhibitor

Review of Progress in Quantitative NDE 2010
San Diego (USA), July, Lectures, Participant

SC10 – International Conference for High Performance Computing
New Orleans (USA), November, Exhibitor

Science Alliance Technologieausstellung auf der Gartenschau in Kaiserslautern
Kaiserslautern, August, Exhibitor

SEG 2010 – International Exposition and 80th Annual Meeting
Denver (USA), October, Exhibitor and lectures

Simulation in der Werkstofftechnik
Nürnberg, October

SIMULIA
Heidelberg, September

SIMVEC 2010 – Berechnung und Simulation
Baden-Baden, November, Exhibitor and lectures

10. Symposium »Textile Filter«
Chemnitz, March, Exhibitor and lectures

Symposium: SIMULATION für robuste Produkte und Prozesse
Bremen, February, Exhibitor and lectures

TER@TEC 2010 Forum
Palaiseau, Paris area (F), June, Exhibitor

Transpore 2010
Villigen (CH), August

VDI/VDE Forum Bildverarbeitung
Regensburg, December, Poster

VISION 2010 – Internationale Fachmesse für Bildverarbeitung
Stuttgart, November, Exhibitor

Workshop Morphologie Mathématique – 70ème Anniversaire Jean Serra
Paris (F), April

Siu, Tak Kuen; Erlwein, Christina; Mamon, Rogemar
Annual Prize for the best paper published:
The pricing of Credit Default Swaps under a Markov-modulated Merton's structural model
North American Actuarial Journal
April

Rieder, Hans; Spies, Martin; Dillhöfer, Alexander
Best Poster Award, DGZfP-Jahrestagung 2010:
Schweißen und Prüfen statt Verschrotten – Zerstörungsfreie sicherheitstechnische Bewertung der Reparatur eines 100 Tonnen schweren Schiffspropellers
Deutsche Gesellschaft für Zerstörungsfreie Prüfung DGZfP
May

Jung, Pascal
Prize of Kreissparkassen-Stiftung for Diploma thesis:
A Discrete Mechanics Approach to Cosserat Rod theory – Static Equilibra
Kreissparkasse Kaiserslautern
July

OWN EVENTS

Exhibition »Begegnungen – Licht & Malerei von Ingo Bracke und Jochen Dewerth«
January

1st Commercial Vehicle Technology Symposium
Kaiserslautern, March

3rd Fraunhofer-Carnot Workshop: 3D Imaging, Analysis, Modelling and Simulation of Macroscopic Properties
Mines Paris Tech, Fontainebleau (F), April, Lectures, Poster, Co-organization

EMS-Workshop in modeling
Bedlewo (PL), October

Felix-Klein-Sommerschule
Kaiserslautern, September

MC-RTN Smart Structures: Training Course on Modeling and Controlling Smart Structures
Fraunhofer ITWM, Kaiserslautern, February

Multiphysics Simulation – Advanced Methods for Industrial Engineering
Bonn, June

mySmartGrid – Projektvorstellung
Fraunhofer ITWM, Kaiserslautern, April

Nacht, die Wissenschaft schafft
Kaiserslautern, October

Seminar: Mehrkörpersimulation in der Betriebsfestigkeit
Kaiserslautern, January; München, September

Seminar: Statistische Methoden in der Betriebsfestigkeit
Kaiserslautern, June

Seminar: Lastdaten - Analyse, Bemessung und Simulation
München, November; Kaiserslautern, December

Special Session: Simulation of Electrochemical Prpocesses, within Numerical Methods and Applications
Borovetz (BG), August

Vortragsreihe des Arbeitskreises Bildanalyse und Mustererkennung Kaiserslautern (BAMEK)
Fraunhofer ITWM, Kaiserslautern, January – December

Workshop »elektro: camp (<<2010>>)«: Open Source Smart Grid Components
Fraunhofer ITWM, Kaiserslautern, October

Workshop »Integer Valued Time Series« im Rahmen des Graduiertenkollegs Mathematik und Praxis
TU Kaiserslautern, September, Mitorganisator

Workshop Mathematik für Personalisierte Medizin
Fraunhofer ITWM, Kaiserslautern, June

Workshop: Application of Hidden Markov Models and Filters to Financial Time Series
In Cooperation with OptiRisk and Carisma, Brunel University, West London (GB), November

Workshop: Data-Mining in der verfahrenstechnischen Industrie
Fraunhofer ITWM, Kaiserslautern, June

Workshop: Image Processing – Trends and Applications
Fraunhofer ITWM, Kaiserslautern, March

Workshop: R with Finance
In Cooperation with OptiRisk and Carisma, Brunel University, West London(GB), November

Workshop: Zinsmodellierung und Bewertung von Zinsprodukten in der Praxis
Fraunhofer ITWM, Kaiserslautern, June

Workshops Fraunhofer-Innovationscluster DNT II »Fahrzeug – Umwelt – Mensch Interaktion«
Kaiserslautern, October

GUESTS

Arnold, Martin (Martin-Luther-University Halle-Wittenberg)
Numerik für Mehrkörpersysteme
March / August / December

Attarakih, Menwer (Al-Balqa Applied University, Al-Salt (JOR)
Population Balance Equations (PBE), QMOM-Methods for PBE, Coupling QMOM to FPM
February/March

Böhlke, Thomas (KIT Karlsruhe)
Thermoelastic properties of pyrolytic carbon: Theory and identification based on microstructural data
October

Bonfigli, Giuseppe (ETH Zürich (CH))
Multiscale Finite Volume Method, CFD
October

Bortfeld, Thomas; Craft, David (Harvard Medical School (USA))
Workshop zur multikriteriellen Optimierung in der Radiotherapie
October

Breuss, Michael (University Saarbrücken)
Morphology and Shape from Shading: Shape Analysis by Hyperbolic PDEs
November

Brox, Thomas (University Freiburg)
Dense point trajectories from optical flow for object segmentation in videos
November

Bruhn, Andreas (University Saarbrücken)
Bewegungsberechnung mit Optimierungsansätzen in Einzel- und Stereobildfolgen: Präzise Modellierung, effiziente Algorithmen und aktuelle Anwendungen
August

Callegaro, Giorgia (Paris (F))
Optimal consumption problems in discontinuous markets
May

Chen, An (University Bonn)
SAHARA-Nutzenfunktion
January

Ciegis, Raimondas (Technical University of Vilnius (LT))
Flows in porous media and parallelization
March

Efendiev, Yalchin (Texas A&M University (USA))
Multiscale problems, Numerical Methods For PDEs, Uncertainty
September-December

Eichfelder, Gabriele (University Erlangen)
Variable Ordnungsstrukturen im Kontext der mehrkriteriellen Optimierung
June

Eymard, Robert (University Paris (F))
Finite Volume Method
February

Gerdts, Matthias (Universität der Bundeswehr München)
Optimalsteuerung
November

Iacus, Stefano (University Milano (I))
On change point analysis for the volatility in discretely observed SDEs
September

Jackson, Myles (New York (USA))
Geschichte Josef von Fraunhofers
June

Köthe, Ullrich (University Heidelberg)
Towards Intuitive Large-Scale Image Segmentation for the Life Sciences
June

Lazarov, Raytcho (Texas A&M University (USA))
Numerical Methods For PDEs
June-July

Löhner, Rainald (Center for Computational Fluid Dynamics, George Mason University, Fairfax (USA))
Particle Methods for Modelling of Pedestrian Flow
September

Mallat, Stephan; Moice, Jeanpierre (Paris (F))
Bildverarbeitung
March

COLLABORATION IN BOARDS, EDITORSHIPS

Miettinen, Kaisa (University of Jyväskylä (SF))
New interactive methods for multiobjective optimization
October

Naess, Arvid (Norwegian University of Science and Technology (N))
The prediction of extreme values of sampled time series by the ACER method; System Reliability Analysis by Enhanced Monte Carlo Simulation
March

Ohlberger, Mario (University Münster)
Multiscale Problems, Model Reduction, Numerical Analysis
March

Ohser, Joachim (University of Applied Sciences Darmstadt)
Die Korrektur von Verschattungseffekten in CLSM-Bildern und ihre Anwendung in der Chromatographie
November

Paulus, Dietrich (University Koblenz)
Umgebungsexploration am Beispiel eines autonomen Haushaltsroboters
Dezmber

Pfrang, Andreas (European Commission, DG JRC Institute for Energy, Petten)
Micro- and nanostructure analysis of PEM fuel cell components: From 2D to 3D imaging
July

Sauer, Mete (ETH Zürich (CH))
Liquidity effects in option pricing
February

Schied, Alexander
A robust strategy for order execution in the Almgren-Chriss framework
December

Singh, R.C. (Sharda University, Delhi (IND))
June

Simeon, Bernd (TU München)
Wissenschaftliches Rechnen in der Festkörpermechanik
April

Spangl, Bernhard (Universität für Bodenkultur Wien (A))
Computing the nearest correlation matrix which is additionally Toeplitz
May

Starikovicius, Vadimas (Technical University of Vilnius (LT))
Numerics for CFD and for flow in porous media
April-May

Tasora, Alessandro (Università degli Studi di Parma (I)
Off-road vehicle dynamics: methods for deformable and granular soil
November

Wardetzky, Max (University Göttingen)
Differentialgeometrie
September

Willems, Joerg (Radon Institute, RICAM, Linz (A))
Multiscale Problems, Numerical Analysis, Numerics PDE
November

Wittum, Gabriel (University Frankfurt)
Scientific Computing, Mathematical Modeling, Multigrid, Multiscale Problems
July

Zheng Harry (Imperial College London (GB))
Regularity of value functions for nonsmooth utility maximization problems
November

Zwiesler, Hans-Joachim (University Ulm)
Mathematische Herausforderungen im Risikomanagement von Lebensversicherungen
June

Didas, Stephan
- Image Processing On-Line (Editor)
- International Journal of Computer Vision (Reviewer)
- Journal of Mathematical Imaging and Vision (Reviewer)
- Pattern Recognition (Reviewer)
- Signal Processing (Reviewer)
- IEEE Transactions on Image Processing (Reviewer)
- International Journal of Electrical and Computer Engineering Systems (Reviewer)
- SIAM Journal on Imaging Sciences (Reviewer)
- Asian Conference on Computer Vision ACCV 2010 (Reviewer)

Dreßler, Klaus
- Proceedings of the 1st Commercial Vehicle Technology Symposium (Editor)

Iliev, Oleg
- President-Elect of the International Society for Porous Media
- Math. Modelling and Analysis (Editorial Board)
- LNCS, Springer (Reviewer),
- SIAM Multiscale Modeling and Simulation (Reviewer)
- SIAM Geoscience (Reviewer)
- Physica D (Reviewer)
- Tranport in Porous Media (Reviewer)
- J.Food Engineering (Reviewer)
- Appl. Math. and Mechanics (Reviewer)
- Austrian Academy of Sciences/ DOC-fFORTE (Reviewer)
- Dutch Technology Foundation STW (Reviewer)

Ilyasov, Maxim
- ACQUIN (Reviewer)

Korn, Ralf
- Dean and member of faculty council Mathematics, University of Kaiserslautern
- Member of the senate, University of Kaiserslautern
- Speaker Research Center $(CM)^2$ University of Kaiserslautern
- Chairman Felix-Klein-Zentrum für Mathematik e.V.
- Member management board Assenagon Asset Management SA, München/Luxemburg
- Deputy chairman Teckpro AG, Kaiserslautern
- CEO EI-QFM, Kaiserslautern
- Publisher of Quantitative Finance (series of Imperial College Press / World Scientific
- Editorial Board: Blätter der DGVFM
- Associate Editor: Mathematical Finance
- Associate Editor Mathematical Methods of Operations Research

Küfer, Karl-Heinz
- Mathematics of Operations Research (Reviewer)
- Medical Physics (Reviewer)
- Zentralblatt für Mathematik (Reviewer)
- Mathematical Programming (Reviewer)

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

Maasland, Mark
- Fraunhofer-Allianz Vision (Member)

Mohring, Jan
- GMA-Fachausschuss 1.30 Modellbildung, Identifikation und Simulation in der Automatisierungstechnik (Member)

Neunzert, Helmut
- Fraunhofer-Carnot (Selection committee)
- Science Alliance (pers. Member)
- Evaluation committee SRG (Karlsruhe Institute for Technology KIT)
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Vice Chairman of the Board)
- Technologie-Botschafter der Stadt und des Landkreises Kaiserslautern

Nickel, Stefan
- Computers & Operations Research (Editor-in-Chief)
- Gesellschaft für Operations Research, GOR (Executive board)

Pieper, Martin
- Heat and Mass Transfer (Reviewer)

Prätzel-Wolters, Dieter
- Forschungszentrum »Center of Mathematical and Computational Modeling CM²« der TU Kaiserslautern (Member)
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Member of the board)
- GAMM-Fachausschuss »Dynamik und Regelungstheorie (Member)
- Präsidium und Senat der Fraunhofer-Gesellschaft (Member)
- Stiftungsrat »Fraunhofer-Zukunftsstiftung« (Member)
- Wissenschaftlich-technischer Rat und Hauptkommission der Fraunhofer-Gesellschaft (Chairman)
- Rat für Technologie des Landes Rheinland-Pfalz (Member)
- Felix-Klein-Zentrum für Mathematik Kaiserslautern (Deputy chairman)

Rieder, Hans
- DGZfP Unterausschuss, Phased Array' im Fachausschuss Ultraschallprüfung (Member)
- VDE/VDI-Fachausschuss »Nichtlineare Systeme« (Member)

Rösch, Ronald
- Image Processing On-Line (Editor)
- Fraunhofer-Allianz Vision (Coordination board)
- Fraunhofer-Allianz Leichtbau (Member)
- Heidelberger Bildverarbeitungsforum (Advisory board))
- IOP electronic Journals (Reviewer)
- GACR (Reviewer)
- Commercial Vehicle Cluster CVC (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)
- Canadian Journal of Statistics (Reviewer)
- Computational Statistics (Reviewer)
- Journal of Statistical Software (Reviewer)
- Journal of the American Statistical Association (JASA) (Reviewer)
- R News (Reviewer)
- Metrika (Reviewer)
- Journal of Statistical Planning and Inference (Reviewer)

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

Schladitz, Katja
- Leichtbau-Cluster (Member)
- Journal of Microscopy (Reviewer)
- Image Analysis & Stereology (Editorial Board und Reviewer)
- Journal of the Royal Statistical Society (Reviewer)
- Scandinavian Journal of Statistics (Reviewer)
- IET Image Processing (Reviewer)
- Scandinavian Journal of Statistics (Reviewer)

Schröder, Michael
- Computers & Operations Research (Reviewer)

Spies, Martin
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e.V. - DGZfP, (persönliches Member, BeiratsMember)
- DGZfP Fachausschuss Ultraschallprüfung (Member)
- DGZfP Fachausschuss Hochschullehrer (Member)
- DGZfP Unterausschuss »Modellierung und Bildgebung« im Fachausschuss Ultraschallprüfung (Vorsitzender)
- Journal of the Acoustical Society of America (Reviewer)
- 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 Computational Acoustics (Reviewer)
- Materials Evaluation (Reviewer)
- NDT&E International (Reviewer)
- Wave Motion (Reviewer)
- Ultrasonics (Reviewer)
- Acustica (Reviewer)

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

Wirjadi, Oliver
- IEEE Transactions on Image Processing (Reviewer)
- Image Analysis and Stereology (Reviewer)

Zemitis, Aivars
- Mathematical Modelling and Analysis, The Baltic Journal on Mathematical Applications, Numerical Analysis and Differential Equations (Editor)

PATENTS

Dalheimer, Mathias; Pfreundt, Franz-Josef
Rechneranordnung mit automatisierter Zugriffssteuerung von einer und Zugriffskontrolle auf eine Applikation sowie entsprechendes Zugriffssteuerungs- und Zugriffskontrollverfahren
Deutsches Patent
DE102008034492A1