Annual Report 2001

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Contents

Preface

One year in the "land of milk and honey" provided by the Fraunhofer-Gesellschaft is over now, so one might be induced to think that the ITWM has become well-fed and lethargic, and the colleagues take a nice little rest with full stomachs in the Garden of Eden. Fortunately, this is not at all the case in reality for one simple reason: the Fraunhofer-Gesellschaft offers a wide range of possibilities for cooperation, and although problems can indeed be harvested everywhere, their solutions must still be searched for. Continuous efforts are required in order to meet new challenges, and this is what keeps us young. The ITWM still has a very lean and extremely effective management despite large amounts of work. The entire overhead expenses were kept at a low level, which enabled us to offer our services on the market at reasonable rates. By their strong engagement for the institute, our highly motivated colleagues have all contributed decisively to the success of the financial year 2001, which resulted in a considerable balance carried forward. Slightly decreasing profits in the field of IT could be compensated by increasing profits in other branches as a positive result of the strong diversification and the wide range of different customers of the ITWM. The operating budget shows a two-digit growth, and in spite of additional public means provided by the BMBF (Federal ministry of education and research) programme "Arbeiten und Leben in einer vernetzten Welt", the economic profits have grown so strongly that the share of profits stemming from industrial cooperation could be stabilized at a level of approximately 45 per cent of the institute's overall budget.

Which were the highlights of 2001?

Our efforts with respect to a European research institute for industrial mathematics based on the ITWM have been carried a large step forward. The Executive Board of the Fraunhofer-Gesellschaft and the Chalmers Technical University have accepted the foundation of a joint venture in Gothenburg, which will be called "Fraunhofer-Chalmers Research Centre for Industrial Mathematics". This center has been initiated by the ITWM and offers best chances for the long-lasting establishment of a research center in Sweden which operates according to Fraunhofer rules. The financial means provided by the Fraunhofer-Gesellschaft in order to develop a respective profile and the financial obligations of the Swedish partner created a firm basis for the operating plan of the new center. Within the next three years, the institute is supposed to employ approximately 20 scientists and twelve PhD students, with an annual budget of approximately two million Euro. Moreover, we expect additional economic profits for the ITWM due to common acquisitions on the Swedish and German markets.

From a local point of view, the year 2001 offered a series of happy occasions with respect to the presentation of awards. A special highlight was the presentation of the **Fraunhofer Award "Simulation of Microstructures"** to the ITWM research group "Microstructure Simulation" on the occasion of the annual meeting of the Fraunhofer-Gesellschaft in Mainz. This new technology allows the simulation of material structures on the computer, their variation and the coupling with flow processes. Particularly with respect to porous media, complex tests and measurement series for the determination of macroscopic material parameters can be substituted by simulations requiring less time and money.

The research group "Computer-based methods for analogous circuit design" has received the **Innovation Award of the *Land* Rhineland-Palatinate** for the development of the software package **"Analog Insydes"**. Analog Insydes stands for Intelligent Symbolic Design System and is applied for the analysis, modeling and dimensioning of analogous circuits which occur in almost every chip. The software is one of the first products of the Fraunhofer ITWM which have been developed exclusively at the institute and are ready for the market now. Symbolic methods of computer algebra are combined with numerical methods, resulting in a new quality of analogous circuit design.

A special pleasure was the personal honoring of Professor Neunzert through the presentation of the **Academic Award of the *Land* Rhineland-Palatinate**. This award, which was presented for the first time, honors his excellent work in research and teaching and his pioneering success with respect to the development of the ITWM.

In many areas, the institute is continuously growing. We are particularly happy about the development of the new **research group FINANCIAL MATHEMATICS,** managed by Professor Korn. The ITWM and the Department of Mathematics are very glad that Professor Korn has remained in Kaiserslaut-

ern despite offers from two renowned universities. Interest in financial mathematics is still increasing at the universities, resulting in a growing competition for experts. Therefore, we are especially pleased that we have been successful on this difficult market in the year 2001 through a series of cooperation projects with renowned financial institutions. Our competence with respect to the development and implementation of new mathematical methods for the modeling and evaluation of enterprise portfolios, as well as of exotic and new derivatives, has shown its relevance in practice. We have made a large step forward on our way to transform the ITWM into one of the leading mathematical competence centers for financial services in Germany.

The strong links to the university and especially to the Department of Mathematics remain one of the most important features of the institute's development. Kaiserslautern belongs to the leading mathematical locations in Europe due to many factors: the quality of research and teaching, international orientation where students from foreign countries are highly welcome, flexible structure of final examinations, and especially the practical orientation of the Fraunhofer ITWM and of several successful enterprises based on mathematics. Kaiserslautern has become an international center for industrial mathematics which is renowned worldwide. Among the different IT locations, this leading position represents a prominent feature of our city which will be emphasized more strongly in the future within the process of developing a special profile as a leading research location in competition with other IT centers. The connection to the university is particularly relevant for the ITWM with respect to human resources. In the last year, this cooperation has been given a new organizational basis through the foundation of a **Fraunhofer College for Industrial Mathematics**. This college will reinforce the external profile of the ITWM as a Center of Excellence in Industrial Mathematics, and organize the internal activities of the institute with respect to training and further qualification, as well as the cooperation with the Department of Mathematics with respect to research and teaching. Further tasks of the college are the decision about its own grants for Master and PhD students of the **graduate school "Mathematics as a Key Technology"**, starting in 2002, and the newly established graduate college "Mathematics in Practice", to which the ITWM is firmly connected with respect to subjects and staff.

The overall number of colleagues working at the ITWM has further increased in 2001, resulting in the need for additional offices at our second location at the PRE Park Kaiserslautern. The division of the institute into two locations can only be accepted as a temporary solution. The course is set for the construction of a new building, so that in the year 2005, the entire institute will hopefully move to the planned Fraunhofer Center in Kaiserslautern.

Now, before you start to enjoy the reading of our annual report, I would like to introduce you to the maybe unusual photographs with respect to the subject "food and drink". Please feel free to listen to your associations and find out how a cup of coffee, a glass of champagne, or a piece of wholewheat bread can be connected to the competences of our institute.

One statement can already be made: The Fraunhofer ITWM offers a rich table where you can help yourself and enjoy the service – almost a land of milk and honey. During the reading, you will certainly acquire the taste!

Professor Dieter Prätzel-Wolters, Director

Profile of the institute

The Institute for Industrial Mathematics was founded in 1995 by members of the research group Technomathematics of the University of Kaiserslautern. As a research institution of the *Land* Rhineland-Palatinate, it was managed from the beginning by the Fraunhofer-Gesellschaft, striving for an integration into the Fraunhofer-Gesellschaft. After a successful evaluation in 1999, the ITWM became a member of the Fraunhofer-Gesellschaft at the beginning of the year 2001 as the first mathematical research institute.

Up to now, three business departments have been established at the ITWM:

- virtual material and product design,
- simulation and optimization of technical and logistics processes,
- diagnosis systems in quality and process control and in medicine.

More than 100 scientists – mainly mathematicians and physicists – in six departments deal with research and application problems especially focused on medium-sized enterprises, without applying expensive experimental and measuring equipment.

The product range includes software developed on the basis of our know-how, offers of consulting and support, and system solutions. Simulation software is not only used at the ITWM, but also developed there, often in cooperation with leading software enterprises.

Our cooperation partners are companies from very different branches, e. g., automobile and aeronautical industry, classical engineering, electronics, and the whole range of textile industry. Other partners are service providers, such as the German Railway and Lufthansa, and research institutes, as well as institutions of the social system.

Today, the ITWM is the spearhead of mathematics in industry, and we intend to strengthen and enlarge this position.

Objectives

The transfer of images of the real world to the virtual world of models and software, and their application for the solution of problems, is of central importance today and refers to all fields of industry, from space technology to textile industry.

Mathematics is the technology required for the creation of these images and their efficient implementation into software, it is the raw material for the models and the basis of each computer simulation. It is the mission and the task of the ITWM to refine this technology, to provide innovative ideas and to apply them in practice in cooperation with industrial partners.

The intention of the ITWM is not only to forge the link between the real and the virtual world, but also to provide a connection between the mathematical research at the universities and the practical application of the results. Therefore, the close cooperation with the Department of Mathematics of the University of Kaiserslautern is especially important.

Organizational Chart

Director	Prof. Dr. Dieter Prätzel-Wolters		+49 (0) 6 31/2 05-44 42
Steering Board	International Matters, Scientific Exchange	Prof. Dr. Helmut Neunzert	+49 (0) 6 31/2 05-27 46
	Division Director	Dr. Franz-Josef Pfreundt	+49 (0) 6 31/2 05-27 44
	Head of Administration	Dr. Marion Schulz-Reese	+49 (0) 6 31/2 05-41 40
	Head of Department	PD Dr. Stefan Nickel	+49 (0) 6 31/2 05-45 58
	Head of Department	Dr. Raimund Wegener	+49 (0) 6 31/2 05-39 26
Departments	Transport Processes	Dr. Raimund Wegener	+49 (0) 6 31/2 05-39 26
	Flow in Complex Structures	Dr. Konrad Steiner	+49 (0) 6 31/3 03-18 20
	Models and Algorithms in Image Processing	Dr. Ronald Rösch	+49 (0) 6 31/3 03-18 67
	Adaptive Systems and Financial Mathematics	Dr. Patrick Lang	+49 (0) 6 31/2 05-28 33
	Optimization	PD Dr. Stefan Nickel	+49 (0) 6 31/2 05-45 58
	Financial Mathematics	Prof. Dr. Ralf Korn	+49 (0) 6 31/2 05-44 71
Central Services	Administration	Dr. Marion Schulz-Reese	+49 (0) 6 31/2 05-41 40
	EDP	Dieter Eubell	+49 (0) 6 31/2 05-44 43
	Public Relations	Dipl.-Math. Steffen Grützner Ilka Blauth	+49 (0) 6 31/2 05-32 42 +49 (0) 6 31/2 05-47 49

Competences and main subjects

- Fluid dynamics:
  - interaction between flow and flexible structures
  - software extensions for FLUENT®, CFX®
- Particle methods for compressible and incompressible flows:
  - airbag deployment
  - refueling processes
- Radiative transfer:
  - cooling of glass
  - radiation transport in biological tissue
- Kinetics:
  - rarefied gas flows
  - traffic flow models
- Simulation-based control and optimization:
  - problems from glass and cement industry
  - construction of loudspeakers
- Simulation of porous media:
  - moisture and heat transport
  - filtration and filter design
- Virtual material design:
  - microstructure simulation
  - computation of material parame ters (flow resistance, acoustic absorption, thermal conductivity, stiffness)
- Filling processes:
  - casting simulation
  - simulation of filling and immersion processes
  - injection molding of fiber-reinforced thermoplastics
- Parallel computing and visualization
- Flood and risk management of municipal sewer systems
- Surface inspection:
  - textured and colored surfaces (e. g., wood, paper, textiles)
- 3D image analysis:
  - geometric characterization of 3D structures
  - modeling of microstructures
  - 3D image processing
- Image and video compression by wavelet methods
- Autonomous control systems
- Analog circuits:
  - symbolic analysis
  - numerical simulation
- Diagnosis and prognosis systems:
  - data mining
  - diagnostics in medicine
- Mechatronic systems:
  - methods of control
  - system identification
- Material models
  - viscoelastic materials with memory
  - homogenization methods for composite materials
- Internal logistics:
  - planning of material flow
  - simulation
  - online optimization
  - hospital logistics
- Inter-company logistics:
  - location planning
  - supply chain management
  - area management
- Traffic management:
  - tariff planning
  - secure connections
- Support of decisions in life sciences:
  - planning of cancer radiation therapy
  - evacuation planning
- Knowledge management and e-commerce:
  - electronic catalogues
  - content management
- Financial mathematics:
  - portfolio optimization
  - option evaluation
  - financial time series
  - financial statistics
  - exotic derivatives
  - Basel II
  - risk management

On our Way to a "European Fraunhofer Institute"?

The first year as a "real" Fraunhofer Institute: many things have changed, even more than we expected – also with respect to internationalization.

Now, there is somebody in Munich taking part in our decisions. However, what this somebody says often makes sense and is very helpful, above all. Certainly, the wind behind us coming from the South has definitely made easier our journey to the North, i. e. to Gothenburg in Sweden, where we have arrived in the middle of the year. In other and more objective words: at the end of August, the "Fraunhofer-Chalmers Research Centre for Industrial Mathematics", the FCC, was founded, representing, as its name already suggests, a real joint venture of the Fraunhofer-Gesellschaft and the Chalmers Technical University, one of the most renowned universities in Scandinavia. "Joint" here means that the basic financial means are provided by Chalmers and the Fraunhofer-Gesellschaft together. And it is a "venture" or, better, an "adventure", because a firm share of the budget, which at the beginning can represent approximately 60 per cent, must be reduced to less than 40 per cent within three years by increasing the profits from industrial cooperation and public projects. However, this is nothing new for the ITWM, who is managing this joint venture for the Fraunhofer-Gesellschaft, it is the same situation as during the years of its foundation. A basic, firm amount of money provided by the ministry had to be transformed to a Fraunhofer financial mix within five years through an increasing number of projects. The ITWM has succeeded very well in meeting this challenge – why should the FCC not succeed, too? The starting conditions in Sweden are even a little better. The "Institut för Tillämpad Matematik" (ITM; tillämpad = applied), a more virtual institute such as the English Smith Institute, has already been distributing project orders and project money of an industrial consortium to university research groups for many years now. Most of the ITM is now part of the FCC; especially its director, Uno Nävert, has now become the director of the FCC. He has connections to the enterprises of the consortium and enjoys a good reputation there. Therefore, he already has a team of eight scientists and industrial cooperation projects with ABB, Volvo, Eriksson, and Astra Zenica. The scientific competence is also represented by the four full board members – two are renowned professors of Chalmers, the German representatives are Professor Prätzel-Wolters and me. Further members are six Swedish "scientific consultants" of Chalmers and the six heads of

the departments of the ITWM. This close connection to the ITWM is not only helpful for the development of the FCC, it is above all intended to reach the underlying objective of such a European Fraunhofer foundation: increasing competence and enlarging markets, also for the Fraunhofer-Gesellschaft. As long as we keep thinking on a more national scale (and paying – after all, half of the basic financial means come from the German taxpayer), the question of the profit for the "donor country" is legitimate and even necessary. So, what is it that the ITWM can now do better that it wasn't able to do before? Which projects have now become possible that were impossible without the FCC?

Before dealing with this question, I would like to repeat a thought from the annual report 2000: half of the basic financial means of a real "European Fraunhofer Institute", with locations in several countries of the EU and with closely connected branches, should be provided by the EU, whereas the other half should come from the country of the respective location. Such a construction would really improve European cooperation, be of concrete help for the acceding countries, and be extraordinarily positive for European economy and science. At the moment, the Fraunhofer-Gesellschaft still is a mainly German organization. However, the European economy is growing together now, and the Fraunhofer-Gesellschaft has a growing interest in European partners.

In Florence, the ITWM has a much smaller joint venture without the help of the headquarters of the Fraunhofer-Gesellschaft. Mario Primicerio, the city's former Mayor who is also an excellent mathematician, has founded a non-profit enterprise for technology transfer. Together with him, the ITWM has started a common project of two person-years. Primicerio knows municipalities and medium-sized enterprises in Tuscany very well and has good access especially to so-called "cooperatives". Together with their Italian colleagues, scientists of the ITWM have visited more than ten such cooperatives; these experiences are also part of the analysis.

First: of course competence is increased by cooperation on a European scale. However, one should mention that international cooperation among mathematicians is already functioning very well anyway. 15 years ago, the "European Consortium for Mathematics in Industry" (ECMI) has been founded, among its founding fathers and mothers Kaiserslautern; two years ago, ECMI has created the research network MACSI, where the ITWM also plays a leading part. MACSI organizes, e. g., workshops on special subjects, such as "Mathematics for Glass Industry" or "Optimal Shape Design", where all interested mathematicians in Europe can meet with enterprises.

Here, colleagues are learning from each other, they know where the adequate experts are and can ask them for information. Even in modern times of networks, the best way to exchange knowledge is via the heads of scientists – they still have the best associations. Knowledge management systems often fail because different languages are used in mathematics, technology, and economy. It is not at all clear that you have to ask an expert for "inverse problems" in order to optimize the design of a lampshade. Thus, heads are still very necessary and must meet. These meetings are improved by joint ventures, although they function relatively well anyway.

However, for the second aspect "access to the market", the Fraunhofer expansions are absolutely necessary. Except for several very large global enterprises, such as ABB or AGIP, an exclusively German research institute will hardly

gain any access to Swedish or Italian enterprises. The access to the Tuscan cooperative, who produces "mouth-made" multicolored wineglasses and is interested in the construction of new, optimized furnaces, would have been impossible without our Italian partners. This is not only a language problem (in Sweden less than in Italy), it is above all a problem of communication, which is, of course, very objective and concise in Sweden, and more profuse and sensual in Italy. It is nearly impossible to gain access to a medium-sized enterprise and establish confidential working relations without a national partner. This is also the case for Germany: Swedish experts will also need German partners who open the doors. I believe that access to the European market is hardly possible without a europeanization of the institutes. This is the main and decisive profit from the joint ventures.

However, we also hope for a more easy access to European financial support for research projects via the Fraunhofer headquarters and the Brussels office. An expansion towards Austria, the Netherlands, and the new acceeding countries appears to make sense also from this point of view.

Last but not least, internationalization helps us to satisfy our need for new colleagues. At the moment, scientists are mainly moving to Sweden. However, sooner or later the brain drain will also flow back again.

Of course, internationalization does not only refer to Sweden and Italy and not only to Europe. Certainly, the greatest supply of brain for us can be found in Eastern Europe, China, India, and Indonesia. Together with the university, the institute has excellent contacts to the institutes of technology in Indonesia and India, and to several Eastern European and Chinese universities. The direct employment of graduates from these universities as scientists at our institute has turned out to be problematic because working and scientific cultures are different, especially in South-East Asia and Eastern Asia. Therefore, we prefer a previous university education of one to two years, during which we are also able to become acquainted with the candidates. In such a way, we have especially won many of our PhD students: intelligent, enthusiastic, hard-working young scientists from all over the world. This is also a form of "absolute solidarity", even with the entire world: working closely together with intelligent and motivated scientists yields profits for their countries and our country Europe.

Helmut Neunzert

FCC Executive Board and Management during the first executive board meeting in Gothenburg in August 2001 (from left): Uno Nävert (FCC), Lars-Göran Löwenadler (Volvo), Dieter Prätzel-Wolters (ITWM), Gunnar Andersson (Livia), Thomas Morsing (AstraZeneca), Jöran Bergh (Chalmers), Helmut Neunzert (ITWM), Peter Jagers (Chalmers), Johan Carlson (FCC)

Fraunhofer College for Industrial Mathematics

The support of young scientists and the close cooperation with the Department of Mathematics of the University of Kaiserslautern have always been very important at the ITWM. The foundation of a Fraunhofer College for Industrial Mathematics in 2001 was supposed to represent an institutionalized platform for these activities. Particular tasks of the Fraunhofer College are the organization of scientific exchange, further qualification, educational activities, and participation in European networks for the ITWM.

The establishment of the new graduate college "Mathematics in Practice" at the department of mathematics by the German Research Society (DFG) and different support programs of the German Academic Exchange Service (DAAD) have increased the number of PhD students who are advised by professors and scientists of the ITWM to 34 in the year 2001. The graduate college and the Fraunhofer College together organize scientific seminars for the PhD students and the scientists of the ITWM, which are also focused on the further qualification of the ITWM scientists.

The number of dissertations, master's theses and other theses written on ITWM subjects has also increased further in the last few years. The Fraunhofer College is supposed to support the efficient organization and coordination of these activities. The early integration of students into the project work of the ITWM is an extraordinarily promising possibility of hiring new personnel with respect to undergraduate assistants, as well as to young scientists. The department of mathematics also profits from a practical education of the students, provided by the integration into ITWM projects. Altogether, the ITWM supports ten students from foreign countries by grants for master's courses.

Highlight:
Fraunhofer award 2001

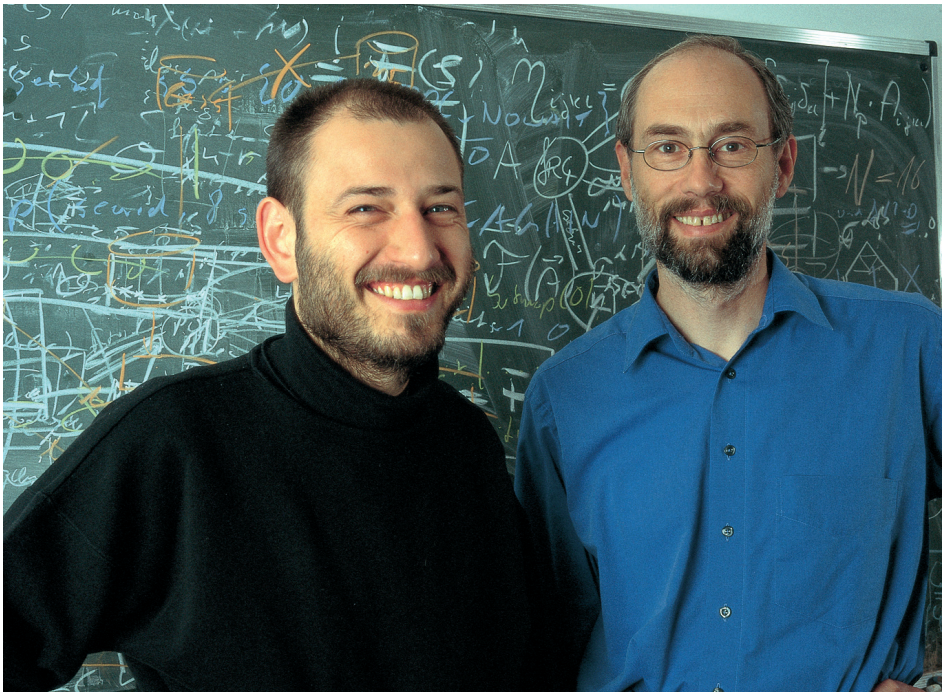
Since 1978, the Fraunhofer-Gesellschaft presents annual awards for excellent scientific results to those colleagues working on the solution of application problems. 2001, three regular awards and a special award have been presented with a prize money of 10,000 euro each.

Cleaning rags on the computer

Cleaning rags should be better at soaking up dirt, diapers are supposed to become smaller and insulating materials lighter. Scientists of the Fraunhofer Institute for Industrial Mathematics ITWM are computing the optimal shape and mixture of the respective fibers.

Why does one cleaning rag soak up dirt better than another? This is due to the form and mixture of the fibers and their structure, is the answer of the researchers in textile industry. However, up to now the appropriate textile structure had to be found by laborious long-time experiments and measurement series. Scientists of the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern open up new paths now. Microstructure simulation enables us to vary material structures on the computer and to compute the exact material parameters simultaneously. On the basis of these data, the product is finally simulated on the computer. Thus, the circle of a complete product development on the computer is closed. The ideas of the research group around Dr. Franz-Josef Pfreundt and Dr. Konrad Steiner enable an entire industrial branch to take advantage of the application of complex mathematical methods.

The method is the result of many individual problems. The scientists, e. g., repeatedly ended up with the problem that material parameters for filters or hygienic products did not exist or were difficult to determine. Additionally, flows in very complex geometries, such as foams or fiber materials, had to be simulated on a microscopic and macroscopic scale. Directed by Dr. Konrad Steiner, the scientists at the ITWM developed a computation method where experiences from projects of the European space technology were also integrated.



Dr. Konrad Steiner (left) and Dr. Franz-Josef Pfreundt accepted the award on behalf of their team of eleven scientists.

Flow simulation became a basic technology for microstructure simulation, since the new method represents a combination of several techniques. "First, tomographic images were produced from existing materials. On this basis, we developed typical 3D structure models", explains the ITWM scientist this new way of product design. The colleagues from Kaiserslautern were supported by the Fraunhofer Institute for Non-Destructive Testing IZFP in Saarbrücken with respect to measurement techniques. "The image data yield the geometric structure of the materials, which is then integrated into computer models. A relatively complex computation of fluid dynamics – including a parallel computer – then gives us the material parameters. These are implemented into special software for the product simulation. If the soaking performance of the fiber structure is not good enough, we can vary the structure of the materials and compute the respective results until we have the optimal properties."

The mathematicians of the still young Fraunhofer Institute are glad about the broad interest of industry in their work. Many enterprises producing porous materials – fabrics, fleeces, papers, and ceramics – have realized that the new method can save much time and money. Meanwhile, Pfreundt and his colleagues know that there is a wide range of new applications for their method. At the moment, the scientists work on the problem of simulating further material properties on the computer, such as the firmness. Pfreundt and Steiner have been working at the ITWM since 1995, and they accepted the Joseph-von-Fraunhofer Award at the annual meeting in Mainz on the behalf of their team of eleven scientists.

Isolde Rötzer
(from the Fraunhofer Magazine 4.2001)

Image acquisition

Light-microscopy image of a fleece

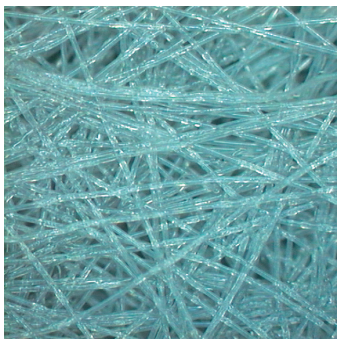
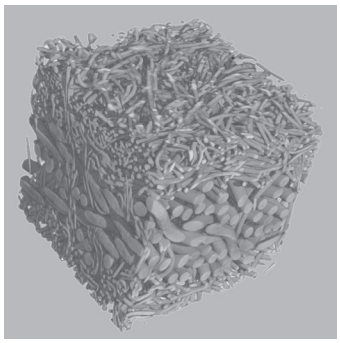


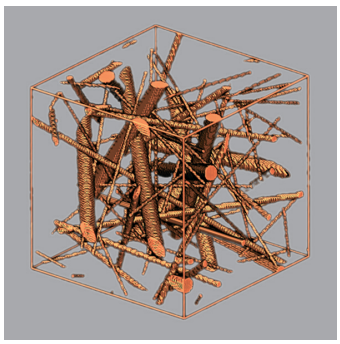
Image analysis

Computer tomographic image of a fleece (© IZFP)



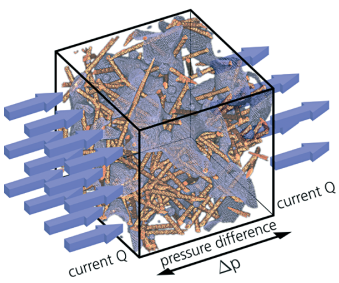
Mikrostructure model

Microstructure model of a fiber material



Mikrostructure simulation

Fluid dynamical simulation in a fiber structure



The Institute in Numbers

Personnel development

In the year 2001, the ITWM was able to further increase its personnel quota by more than 20 per cent. The ITWM did profit from the slightly improving situation on the job market and from its previous engagement with respect to the support of in-house young scientists.

2001, the personnel of the ITWM comprised more than 100 colleagues (63 scientists, 30 PhD students, and 10 colleagues in central departments), as well as 70 scientific assistants and trainees.

The high qualification of the ITWM scientists is also shown by the fact that 40 out of the 63 colleagues, i. e. 63 per cent, have a PhD degree. Most of the scientists, i. e. 73 per cent, are mathematicians, followed by physicists and engineers (11 per cent each), as well as computer scientists.

Particularly with respect to new PhD students and scientific assistants, the ITWM can take special advantage of the international courses at the department of mathematics, where excellent foreign students are present. Thus, the quota of scientists from foreign countries is 16 per cent, the quota of foreign PhD students is even 57 per cent, and there are just under 50 per cent of foreign assistants.

In the last few years, the quota of female colleagues has also clearly increased at the ITWM, i. e. to 14 per cent of the scientists and 23 per cent of the PhD students.

Thus, the common efforts of the ITWM and the department of mathematics to support the internationalization of the university education and to intensify the support of interested pupils already at school, have shown first results.

Development of personnel	1998	1999	2000	2001
Scientists	43	45	54	63
PhD students	13	17	19	30
Central Services	6	7	8	10
Research assistants	29	48	60	70
Other employees	8	8	11	13
Total	**99**	**125**	**152**	**186**

Budget

The first year in the Fraunhofer-Gesellschaft was a very successful year for the ITWM.

Although the final close of accounts for the year 2001 takes place after the deadline for the annual report, we can already state that the result has more than met the expectations.

Certainly, as a member of the group for information and communication technology in the Fraunhofer-Gesellschaft, the ITWM did profit from the merger projects financed by the BMBF on the occasion of the integration of the GMD institutes into the Fraunhofer-Gesellschaft. They undoubtedly contributed to the result that in 2001, almost 83 per cent of the operating budget consisted of the institute's own profits. Despite the considerable increase with respect to profits from public projects, the ITWM was again able to make high profits from industrial projects, as in the past few years.

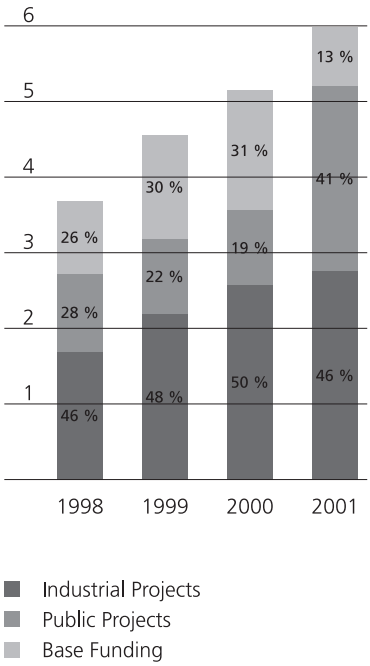
For the year 2001, the operating budget will reach approximately 6 million euro. Almost 4.9 million euro are the institute's own profits, of which 2.7 million euro represent profits from industrial projects.

In 2001, the ITWM was for the first time able to profit from the internal programs of the Fraunhofer-Gesellschaft. The institute received approximately 200,000 euro for the foundation of the Fraunhofer-Chalmers Research Centre, as well as for common studies with other Fraunhofer Institutes.

With respect to investments, the ITWM also participated in the internal programs. More than 600,000 euro were granted for the acquisition of a parallel computer and visualization hardware.

Compared to the previous year, the operating budget has increased by a considerable 17 per cent. We would like to point out that this positive result is the common merit of all the departments.

Development of Budget
in Mio €



Development of Budget [Thousand €]	1998	1999	2000	2001 (provisional)
Business	3 681	4 550	5 147	5 976
Investments	460	382	244	756
Total	**4 141**	**4 932**	**5 391**	**6 732**

Clients and project partners

For many years now, the ITWM has successfully cooperated with enterprises of different sizes and from many branches. In the following, those project partners of the year 2001 are listed who have accepted to be cited.

- Amaranth Advisors, New York
- Analog Microelectronics GmbH, Mainz
- aquinto AG, Berlin
- Atmel Germany GmbH, Heilbronn
- Audi AG, Ingolstadt
- AVL List GmbH, Graz
- Bavarian State Ministry for Regional Development and Environmental Affairs
- BGS Systemplanung, Mainz
- Boehringer Ingelheim Pharma KG, Ingelheim am Rhein
- Caparol Farbe Lacke Bautenschutz GmbH & Co Vertriebs KG, Ober-Ramstadt
- CargoLifter AG, Berlin
- Carl Zeiss, Oberkochen
- Christian Heinrich Sandler GmbH & Co. KG, Schwarzenbach (Saale)
- DaimlerChrysler, Stuttgart
- DePfa Bank, Wiesbaden
- Deutsche Bahn AG, region Frankfurt/Main
- German Society of Onkology, Cologne
- Deutsche Rückversicherung AG, Düsseldorf
- Deutscher Wetterdienst, Offenbach/Main
- Deutsches Krebsforschungszentrum, Heidelberg
- Dresdner Bank, Frankfurt
- ESI-Group, Paris
- Faurecia, Sassenburg
- Filterwerk Mann + Hummel GmbH, Speyer
- Freudenberg Vliesstoffe KG, Weinheim and Kaiserslautern
- ganiMed GmbH, Freiburg
- gbo AG, Rimbach
- geomer, Heidelberg
- GE Transportation Systems, Bad Dürkheim
- Glatz Feinpapiere, Neustadt/Wstr.
- HegerGuss GmbH, Enkenbach-Alsenborn
- Hershey Foods, USA
- Hilti AG, Schaan (Liechtenstein)
- HypoVereinsbank, Munich
- ICON Industrie Consulting GmbH, Karlsruhe
- Imtronic, Berlin
- Infineon Technologies AG, Munich
- Institut für Gießereitechnik GmbH, Düsseldorf
- J. Wagner GmbH, Markdorf
- KS Beschallungstechnik GmbH, Hettenleidelheim
- Landesbank Baden-Württemberg
- Landesbank Rheinland-Pfalz, Mainz
- m2k Informationsmanagement GmbH, Kaiserslautern
- MAGMA Gießereitechnologie GmbH, Aachen
- Mannesmann-Rexrodt AG, Lohr a. Main
- Medical Data Research GmbH, Düsseldorf
- MiniTec GmbH & Co KG, Waldmohr
- MVT Maschinen- und Verfahrenstechnik Bernhard Blatton GmbH, Dillingen
- Nahverkehrsservice Sachsen-Anhalt GmbH (NASA), Magdeburg
- NEUMAG GmbH & Co., Neumünster
- Pfleiderer AG, Neumarkt
- PHB Stahlguss International, St. Ingbert-Rohrbach
- Pierau Planung, Hamburg
- psb GmbH, Pirmasens
- Regionalbus Saar-Westpfalz GmbH (RSW), Saarbrücken
- SAP AG, Walldorf
- Schott Glas, Mainz
- SIEDA Software GmbH, Kaiserslautern
- Siemens AG (KWU), Mülheim/Ruhr
- Stadtentwässerung Kaiserslautern
- Steinbichler Optotechnik GmbH, Neubeuern
- Technical University of Dresden
- tecmath AG, Kaiserslautern
- Tehalit GmbH, Heltersberg
- Thomas Josef Heimbach GmbH & Co., Düren
- University of Kaiserslautern
- Verein Deutscher Gießereifachleute (VDG), Düsseldorf
- Verkehrsverbund Rhein-Neckar GmbH (VRN), Mannheim
- Verkehrsverbundgesellschaft Saar mbH (VGS), Saarbrücken
- WestLB, Düsseldorf
- Westpfalz Verkehrsverbund GmbH (WVV), Kaiserslautern

Board of trustees

The constitutive meeting of the new board of trustees was held on February 19, 2002. As members, renowned representatives from science, industry, and politics could be won, among which are:

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Deutsches Zentrum für Luft- und Raumfahrt e. V. DLR, Bonn

Dr.-Ing. Erwin Flender
MAGMA Gießereitechnologie, Aachen

Ministerialrat Wolfgang Habelitz
Ministerium für Wissenschaft, Weiterbildung und Kultur, Mainz

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Dr. Wilhelm Krüger
tecmath AG, Kaiserslautern

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Dr. Horst Loch
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The Fraunhofer-Gesellschaft at a glance

The Fraunhofer-Gesellschaft is the leading organization for institutes of applied research in Europe, undertaking contract research on behalf of industry, the service sector and the government. Commissioned by customers in industry, it provides rapid, economical and immediately applicable solutions to technical and organizational problems. Within the framework of the European Union's technology programs, the Fraunhofer-Gesellschaft is actively involved in industrial consortiums which seek technical solutions to improve the competitiveness of European industry.

The Fraunhofer-Gesellschaft also assumes a major role in strategic research: Commissioned and funded by Federal and *Länder* ministries and governments, the organization undertakes future-oriented research projects which contribute to the development of innovations in spheres of major public concern and in key technologies. Typical research fields include communications, energy, microelectronics, manufacturing, transport and the environment.

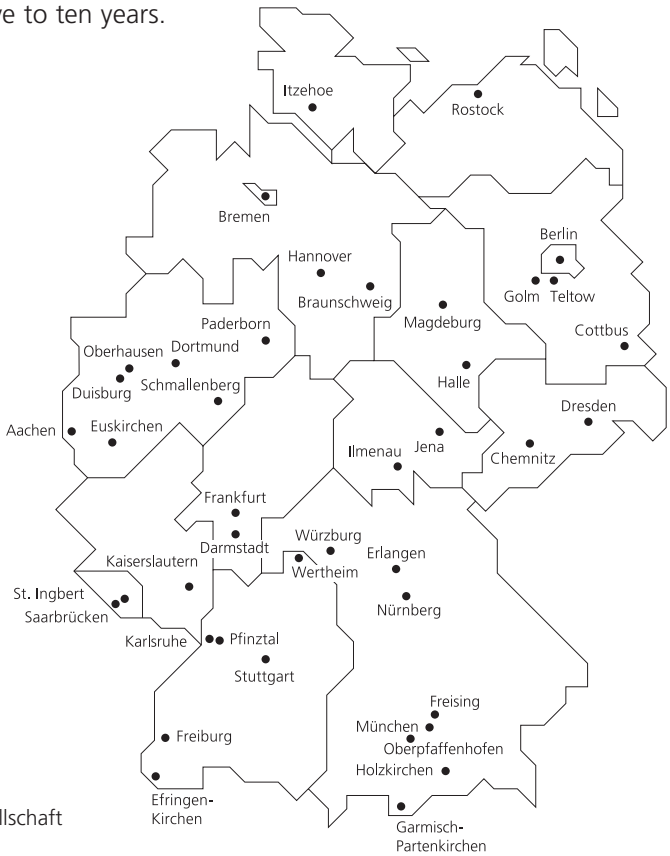
The global alignment of industry and research has made international collaboration imperative. Furthermore, affiliate Fraunhofer institutes in Europe, in the USA and in Asia ensure contact to the most important current and future economic markets.

At present, the organization maintains 56 research establishments at locations throughout Germany. A staff of some 11,000 – the majority of whom are qualified scientists and engineers – generate the annual research volume of more than 900 million euro. Of this amount, over 800 million euro is derived from contract research. Research contracts on behalf of industry and publicly financed research projects generate approximately two thirds of the Fraunhofer-Gesellschaft's contract revenue. One third is contributed by the Federal and *Länder* governments, as a means of enabling the institutes to work on solutions to problems that are expected to attain economic and social relevance in the next five to ten years.

Fraunhofer scientists specialize in complex research tasks involving a broad spectrum of research fields. When required, several institutes pool their interdisciplinary expertise to develop system solutions.

The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. Its members include well-known companies and private patrons who contribute to the promotion of its application-oriented policy.

The organization takes its name from Joseph von Fraunhofer (1787-1826), the successful Munich researcher, inventor and entrepreneur.



Locations of Fraunhofer-Gesellschaft in Germany

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Sittting: Cäcilie Kowald, Dr. Marion Schulz-Reese, Dieter Eubell

Transport Processes

From an economic point of view, up to now 2001 has been the most successful year for the department of TRANSPORT PROCESSES. This success is not only based on an increasing number of customers, but also on their remarkable loyalty. The department works on a well-balanced basis between the development of a typical profile, represented by the fields of competence described in the following, and a necessary amount of flexibility, reflected by industrial projects also on the boundary of this spectre. Of course, this second aspect, which is an essential part of a vivid project work, cannot be dealt with sufficiently in an annual report for reasons of confidentiality.

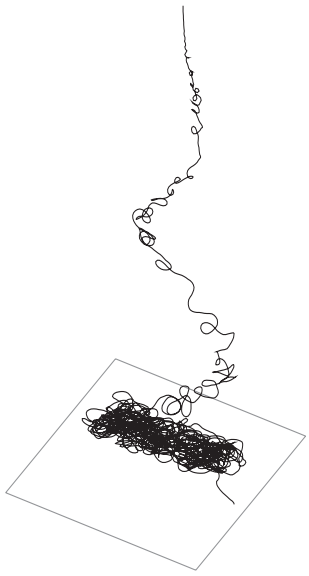
The department's fields of competence are reinforced systematically by the work on specific research subjects. In the field of "Fluid Dynamics", e. g., we concentrate mainly on problems of fluid-structure interaction. Our fluid dynamical software based on a particle method ("Finite Pointset Method"), which has been developed at the ITWM for compressible flows, can now also be applied for the computation of incompressible flow problems. In the field of "Radiative Transfer", our range of applications has increased from semi-transparent media, e. g., glass, to strongly scattering media, such as biological tissue. The know-how with respect to mathematical modeling and simulation of a large area of transport processes, which is reflected in the mentioned subjects, is completed by a distinctive competence of combining these simulations with optimization problems or integrating them into control problems. Here, the method of adjoint operators has been adapted to our research problems (particularly for the solution of continuous optimization problems), and has already been applied successfully in industrial projects.

The exchange between basic and contract research remains intact and is always stimulating for both sides. Evidence are, e. g., four new PhD projects with respect to the subjects of the department, which will give important impetus to the project work of the next few years.

Fluid Dynamics

The fluid dynamical problems dealt with in the department of TRANSPORT PROCESSES primarily stem from the context of production or process engineering. Typical examples are the analysis of a process or the simulation-based design of a machine. The special competence of the research group is the comprehensive mathematical modeling and solution of complex problems, where fluid dynamical problems often only represent a partial aspect. Depending on the application problem and the desires of the customer, analytical methods, simulations with licensed software tools (FLUENT®, CFX®), and especially developed software are combined.

In the past, the work has increasingly focused on the field of fluid-structure interaction, to which a large part of this year's finished projects is also related. Together with the company Freudenberg Vliesstoffe KG, we have developed a method for the simulation of fleece production, which is based on a model of the movement of filaments in an air flow. The large number of filaments in the production process requires efficient numerical modeling and the application of parallel computers for the simulation. Apart from filaments, the problem of flexible structures subject to flows also refers to the simulation of two-dimensional structures, such as sheets or foils. The analysis of the respective production processes results in new possibilities for process improvement and can reduce considerably the amount of time and money required for measurement series.



Simulation of fleece production: oscillating polymer filaments are deposited on a transport belt. The air flow is decisively important for the quality of the fleece.

The dynamics of firm particles or droplets interacting with a flow is another aspect of the fluid-structure problem. Within the project "NESPRI", which is funded by the "InnoNet" program of the Federal ministry for economics and technology (BMWi) for the support of innovative networks, an association of several painters, a producer of paint, a producer of painting devices, and three research institutes intends to develop a new method for the mist-free spraying of claddings, and to establish this method in business. Apart from the coordination of this integrated project, the Fraunhofer ITWM deals with the mathematical modeling and simulation of the different technical aspects. The overspray occurring during the application of already existing methods could be traced back and quantified by the simulation of the tiny paint droplets created during the spraying process. The intended reduction of the overspray to its cause will be reached by extensive measurement and experimental campaigns of the other project partners and by analytical examinations of the Fraunhofer ITWM. The latter will particularly provide a rule of thumb for the estimation of the smallest sizes of the occurring droplets, depending on the turbulence structures of the air flow, the rheology of the paint, and the essential process parameters.

Apart from the field of fluid-structure interaction, the project work is focused on fluid dynamical problems where aspects of heat balancing are dominating. An example is the cooperation with the company ARRI, a leading producer of floodlights for motion pictures and television. Such floodlights must be cooled exclusively through convection, in order to avoid disturbing sounds produced by cooling fans. In a feasibility study, a concept has been developed, on the basis of which the geometry of floodlights can be optimized with respect to their cooling behavior. The long-term intention is to include the control of the heat balance through simulation into the standard floodlight design.

The activities described above suggest a combination of the know-how with respect to technical aspects of production processes, available in the research group "Fluid Dynamics", with the field of competence "In-house Logistics" of the department of OPTIMIZATION. The project "SILVER", in the framework of a program of the Federal Ministry of Education and Research (BMBF) "Leben und Arbeiten in einer vernetzten Welt", has now enabled us to realize this idea (compare also page 81).

The projects of the research group "Fluid Dynamics" are realized in close cooperation by Dr. Dietmar Hietel (phone: 06 31/2 05-40 82), Dr. Robert Feßler and Dipl.-Ing. Sergej Antonov.

Temperature field simulation: in a floodlight, heat is mainly concentrating in the upper section.

Spray painting of a cladding: neighboring parts must be protected from the resulting mist of paint.

Finite Pointset Method

The deployment of an airbag, the behavior of a multiphase flow in a stirrer, or the metal cutting of a production piece are all processes which can be modeled in large parts by partial differential equations. Nevertheless, the simulation of these problems causes considerable problems, because the standard grid-based methods, such as finite elements, finite differences, or finite volumes, come up against limiting factors here. The basic reason for these difficulties is the partially extreme variation of the computing domain during the respective process. Particularly with respect to three-dimensional problems, the existing methods for the dynamical grid adaptation, such as Moving Grids and remeshing, fail or require inacceptable computing times.

Particle methods for the numerical solution of partial differential equations avoid these difficulties. The computing domain is covered with a set of particles which, in contrast to the meshes of a grid, can be adapted to the dynamics of the problem. In the past few years, the Finite Pointset Method (FPM) has been developed at the ITWM, an independent software tool whose origins are in the so-called SPH method (Smoothed Particle Hydrodynamics).

Originally, FPM has been developed for compressible gas flows, functioning in the following way: the fluid dynamical equations to be discretized (Euler respectively Navier-Stokes equations) describe the time-dependent development of the density, flow velocity, and temperature fields as a result of the physical conservation laws for mass, momentum, and energy. The values of these fields are stored at the discrete positions of the particles and can be computed by an appropriate approximation method at each point of the flow field together with all the necessary spatial derivatives. In one time

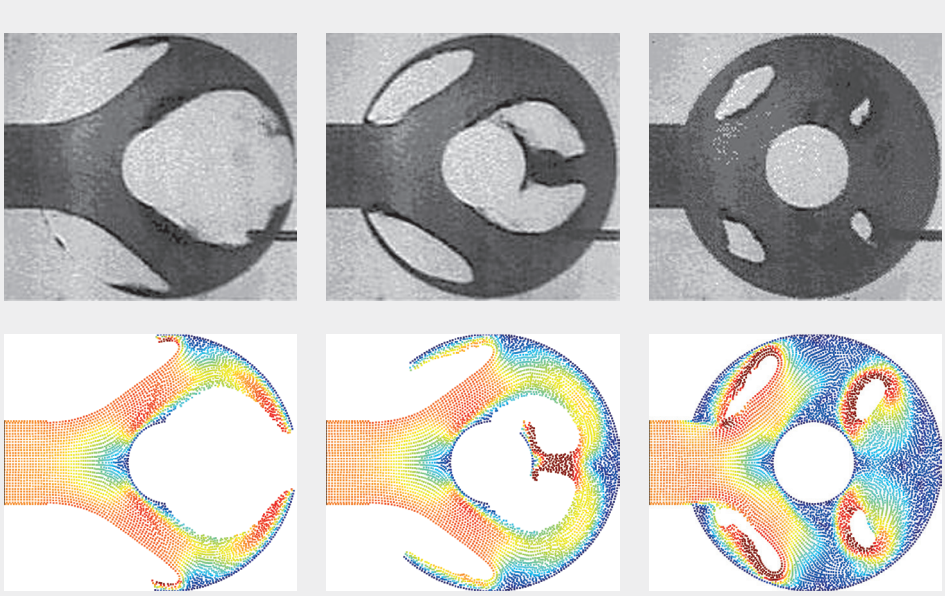
step, the particles are now moved with the approximated velocity. The values for the fluid dynamical fields at the new particle positions result from the solution of basic equations in Lagrangian form through the application of the mentioned approximation strategy. It is this approximation strategy, which must guarantee an efficient and exact computation of the fields and their derivatives, that is the special feature of the method. Apart from a moving least square method for problems of gas dynamics, a special upwind method is applied at the Fraunhofer ITWM. The development of FPM for compressible flows has been carried so far that even complex industrial applications can be computed now. The project "airbag deployment" described below (cf. p. 28) represents a convincing example.

This year, the research activities were particularly focused on the adaptation of the method to incompressible flow problems. The special feature of the method developed at the Fraunhofer ITWM is the complete solution of the Poisson equation, which is required for the pressure, by a particle method. This is done according to the projection method of Chorin, which is known from grid-based methods. At the moment, the research concentrates on the acceleration of the code through multigrid methods.

The developments in the field of incompressible flows essentially take place within the project "Ecologically Harmless Refueling", financed by the company VW and the Federal Ministry of Education and Research (BMBF). The main subject is the examination of foaming during refueling processes. In the following, a first application of FPM for incompressible multiphase flows will be described within the project "Streaks in Glass Flows".

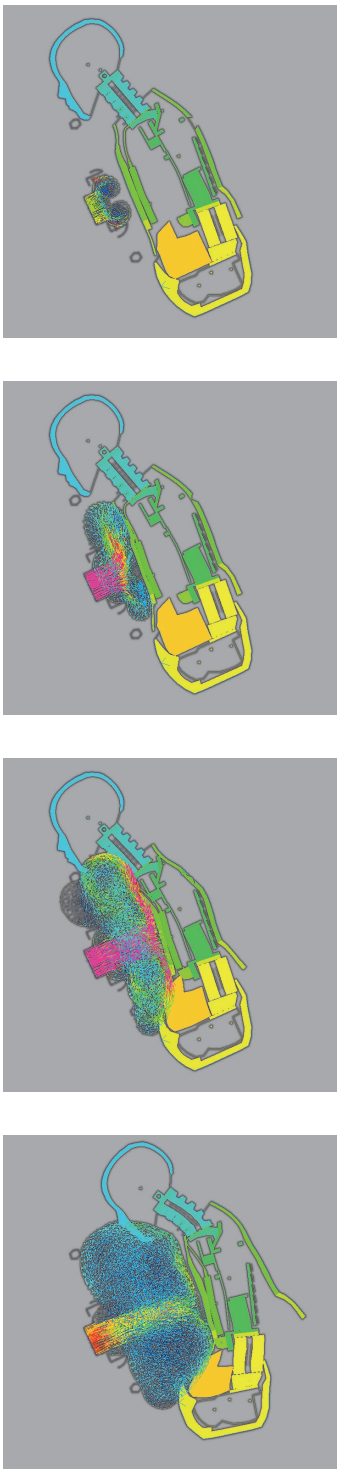
In the future, we intend to adapt FPM to structure mechanical problems. On a long-term range, the objective is the solution of complex problems, such as the simulation of the metal cutting production processes mentioned above. Our medium-term intention is the application of FPM to subjects of fluid-structure interaction, as they result from the projects of the research group "Fluid Dynamics".

At the ITWM, FPM is developed by Dr. Jörg Kuhnert (phone: 06 31/2 05-40 87) and Dr. Sudarshan Tiwari, in cooperation with several PhD students.



Study of a filling process: the upper figures show the filling process during an experiment, the figures below represent the simulation by FPM.

Airbag deployment



Interaction of airbag and passenger: the simulation represents the pressure distribution during the airbag deployment, showing the forces to which the driver is subject.

The deployment of an airbag is a very complex physical process. In cooperation with the company ESI, we develop a software tool for the producers of automobiles and airbags, which is able to simulate the deployment process of an airbag very well, even if the airbag is folded in a very complex manner. The simulations carried out with this tool are supposed to provide better information about the interaction of the deploying airbag and the passengers of the car. The underlying problem is the question of injuries, i. e. the question whether the airbag actually reduces injuries in the case of an accident, or even causes more damages in certain situations.

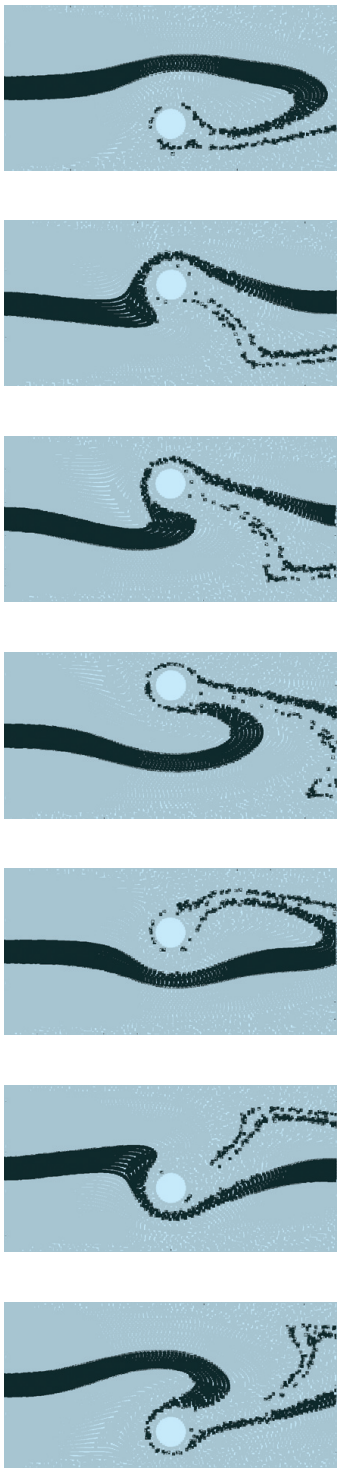
In the simulation, the dynamics of the gas in the interior of the airbag is dealt with at each time step by the finite pointset method (FPM) developed at the Fraunhofer ITWM. Essentially, the application of FPM yields the pressure distribution at the airbag membrane. A second finite element software, developed by the company ESI, then describes the dynamics of the airbag membrane depending on the pressure distribution, resulting in the new airbag geometry. This new geometry is used as input for FPM in order to compute the gas dynamics of the next time step. Thus, the full dynamics of the membrane during the deployment process is determined successively. The acceleration of the membrane is the main reason of the forces to which the passenger is subject.

During the year that has passed now, essential progress has been made with respect to the stability and computing performance of the software, which is of decisive importance for the users of the tool. Last year, we were already able to prove that FPM yields very exact results, which was shown by experiments with unfolded airbags. The experiments with respect to completely folded airbags, which have been initiated in the last few months, are supposed to be integrated into the validation of the tool next year.

Streaks in glass flows

During glass production, streaks often occur in the glass melts. These are undesired pollutions of the glass originating at the walls of the glass tank or in channels and pipes where the glass flows. The streaks have different physical properties compared to the glass melt. In particular, density and viscosity of the streaks and the glass are different. From a technical point of view, it is extremely difficult to avoid the formation of streaks completely. In comparison, the homogenization of already existing streaks in the molten glass through stirrers appears to be essentially more easy. However, since molten glass is an extremely viscous medium, the optimization of the stirrers is especially important because a mixing of the glass without turbulence can hardly be realized.

The basic idea of this project, commissioned by the company Schott Glas in Mainz, is the verification of the stirrer's effectivity by simulations and the testing of variations of the stirrer geometry, if necessary. We consider the flow of a two-phase medium (glass and streak) and develop a numerical model for the dynamics of the streak within the stirrer. Principally, the application of FPM is very much appropriate here, because it is able to describe moving phases and geometries inherently by its Lagrangian formulation. However, the streaks are very thin, which results in a special technical problem: the necessary resolution requires considerable computing times, which are still unsatisfying, particularly with respect to the optimization objectives of the project. A possible solution of the problem can be a numerical resolution on an adaptive basis with a very strong refinement of the streaks. In the following year, this task, which is far from simple, will be the subject of the next part of the project.



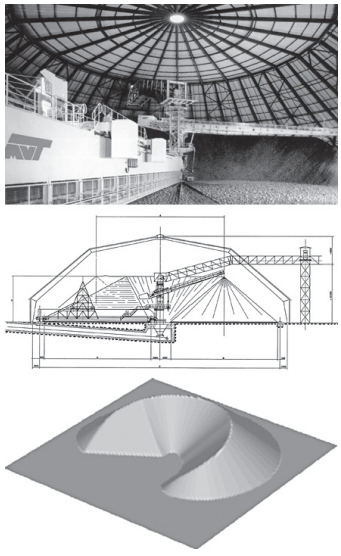
Dynamics of streaks in a stirrer: this two-dimensional study shows how streaks expand and change during the stirring.

Control, Optimization, Inverse Problems

The modeling and simulation of different transport processes is the general subject of the department. For an institute of applied research, such simulations are very often not the final objective. Although in several cases the customers are only interested in a basic understanding of their processes or their machines, in general there are much more further-reaching mathematical subjects determined by optimization and control problems. It is a long-term scientific challenge for the department to couple these subjects with its own specific competence, i. e. with the simulation of transport processes on the basis of partial differential equations.

In the following, the project "Equalization of Bass Speakers" will give an example from acoustics which belongs to the field of control problems. Considerable progress has also been achieved in the research work with respect to the coupling of the simulation of stacking processes of granular materials with the control of the respective material supply. Here, with the software PHARAO the ITWM can offer a software solution based on Matlab/C++ to interested customers especially from cement industry. For more information please refer to the annual report 2000 and to the internet pages of the institute.

In the past year, the industrial projects were mainly dominated by problems of the following type: How is the optimal geometry of a component in order to provide specific properties? How does a production plant have to be controlled in order to guarantee a certain quality of the products? How can material parameters that may be difficult to achieve be deduced from easily feasible measurements?



Simulation of a round mix bed with the ITWM software PHARAO

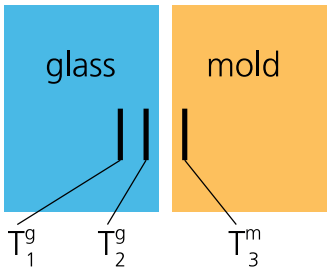
The mathematical modeling of a large number of these problems leads to so-called inverse problems: we observe a special effect, and we want to deduce its cause. One example has already been described in the annual report 2000 on page 27: the determination of the temperature distribution in hot glass by a spectrometer measurement of the spectral radiative intensity. In general, the inverse problems in question are – mathematically speaking – "ill-posed", i. e. they cannot be solved uniquely, or a very small measurement error can result in inacceptable errors in the reconstruction. Apart from the classical regularization methods for the solution of inverse problems, the formulation of these problems as optimization problems offers a very efficient approach for their mathematical solution. Therefore, during the last year the work was strongly focused on the method of adjoint operators, which will be shortly explained by the following example.

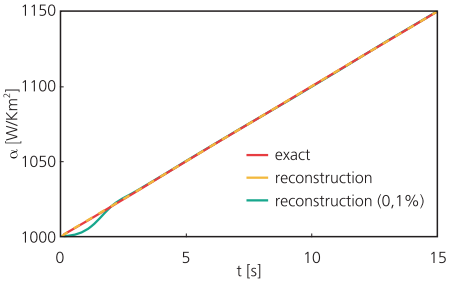
In order to determine the coefficient of heat transfer between a hot glass melt and the surrounding mold, time-dependent temperature measurements are carried out at individual, easily accessible points in the glass and in the mold. Now, the coefficient of heat transfer must be determined in such a way that the difference between measured and simulated temperatures is as small as possible. The temperature field of the heat transfer equation must serve as a sufficient constraint. Then, the determination of the coefficient of heat transfer can be formulated as an optimization problem with a constraint. With a Lagrange approach, an algorithm can very easily be derived which not only yields the solution of the heat transfer equation, but also the solution of an adjoint equation.

Apart from the determination of the coefficient of heat transfer between glass and mold by this method, the methodical approach described above has also been applied successfully to problems from other industrial projects. Examples are the shape optimization of a thermo-electrical flange, the control of the furnace temperature for the optimization of special glass properties, as well as the temperature determination in the interior of hot materials by measuring special surface properties. The main partner in these industrial projects is the company Schott Glas in Mainz.

Future activities will especially focus on coupled heat transfer and thermal radiation problems.

Dr. Jan Mohring (phone: 06 31/2 05-38 86) is working on the subject "Simulation and Control", whereas Dr. Norbert Siedow (phone: 06 31/2 05-41 26) mainly concentrates on "Optimization and Inverse Problems".





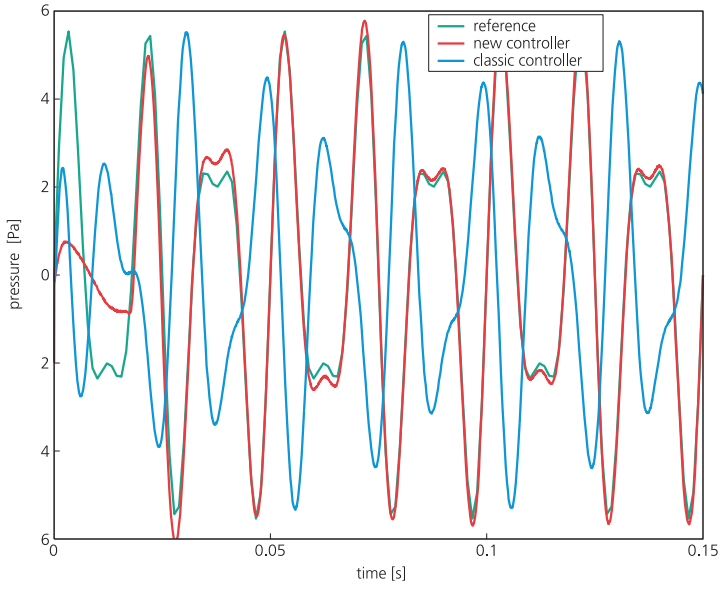
Reconstruction of the time-dependent coefficient of heat transfer during the casting process of glass: the upper figure shows the schematic structure with three measuring points in the glass and in the mold, the figure below represents the reconstructed coefficient of heat transfer, in comparison with the exact value. Deviations can only be recognized at the beginning.

Equalization of bass speakers

The project presented here has been carried out in close cooperation with the company KS-Beschallungstechnik, one of the most renowned addresses for expert sound systems. The company is already using digital signal processors (DSP) very successfully in order to produce mid-range and treble loudspeakers with a unique sound reproduction. The applied filters use as input the impulse response stored in the memory. However, this technique cannot be transferred to bass speakers, because high performance for low frequencies requires a strong excursion of the membrane or hardly damped resonances of the box. Both effects result in a long reverberation time and nonlinear effects like the superproportional occurrence of overtones if the performance is increased (distortions). The objective of the common R&D project is the compensation of these effects through a new control concept realized by DSPs, as well as through the simulation-based shape optimization of the box.

The controller is supposed to determine the voltage at the moving coil in such a way that, on the one hand, the sound pressure produced follows the incoming signal (e. g., CD) as exactly as possible, and on the other hand the electric and mechanical loads remain uncritical. From a control theoretical point of view, we are thus dealing with the problem of an optimal tracking. The required quality of this feedback, the strong nonlinear individual dynamics of a bass speaker, and the real-time computation represent a challenge that is not even met by regulators developed especially for nonlinear systems. The method of feedback linearization (mirror filter), e. g., does not include a mechanism to limit energy.

The concept developed at the Fraunhofer ITWM generalizes the principle of an optimal linear output-feedback. It is based on a nonlinear state space model of the speaker, which describes how the state variables, e. g., current or membrane excursion, change depending on the control voltage. In particular, the method allows the forecast of the sound pressure as a function of control voltage and original state. This forecast can be compared with a section of the incoming signal anticipated



Simulated transient response of the prototype in the case of the new regulation and in the case of classical linearization of the amplitude frequency response

by a few milliseconds. Finally, the control voltage is selected in such a way that the resulting difference, as well as the energy stored in the speaker, remain as small as possible. The central problem is the symbolic approximation of the occurring differential equations and optimization problems in such a way that the voltage is represented as a polynomial in the original state and the incoming signals. The solution arises from an unconventional coupling of computer algebra and asymptotic analysis.

In order to realize the control concept on a DSP in a simple way, a software package has been developed at the Fraunhofer ITWM which automates all the necessary process steps, from the identification of the nonlinear state space model on the basis of measurements to the output of the polynomial coefficients essential for the controller. At the moment, the hardware integration of the DSP is not yet finished. If the regulated bass speaker behaves as it does in the simulation, the sound reproduction will correspond to the quality of the mid-range and treble speakers in every way, so that the product line of KS-Beschallungstechnik will be rounded off.

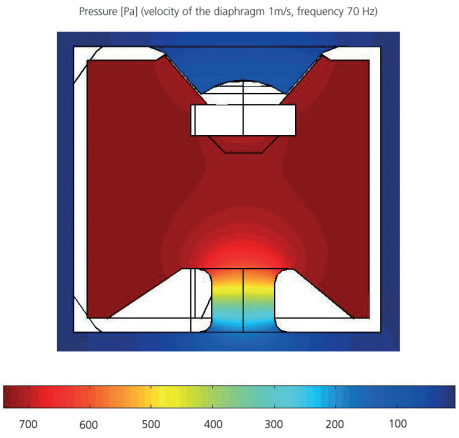
The second part of the project has dealt with the problem of finding a box geometry which already suppresses disturbing distortions by its shape. This nonlinear phenomenon cannot be simulated by commercial acoustic software because the latter is based on the linear Helmholtz equation. Therefore, at the Fraunhofer ITWM an approximation of the Euler equation has been derived which accounts for the membrane excursion of second order. It turns out that the sources of disturbing overtones are the areas of high pressure, as well as those areas where the velocity is rapidly changing. The new equations were implemented under Femlab, a commercial finite element package. In particular, the nonlinear sound field simulation uncovers that insufficiently rounded edges of the reflex tube are disturbing. Although this has already been known for a long time, only now a quantitative determination is possible. The additional numerical effort is small compared to a linear acoustic simulation, it only requires the solution of one further inhomogeneous Helmholtz equation.

$$
\begin{aligned}
P &= \rho_0 c^2 \left\{ \varepsilon \tfrac{1}{2}\left(p_1 e^{i\tau} + \bar{p}_1 e^{-i\tau}\right) \right. \\
&\quad \left. + \varepsilon^2 \left(\tfrac{1}{2}\left(p_2 e^{2i\tau} + \bar{p}_2 e^{-2i\tau}\right) + q_2 \right) \right\} \\
&\quad + O(\varepsilon^3) \\
(\Delta + I) p_1 &= 0 \\
(\Delta + 4I) p_2 &= \left(\gamma - \tfrac{1}{2}\right) p_1^2 + \tfrac{3}{2} \sum_{i,j=1}^{3} \left(\frac{\partial^2 p_1}{\partial \xi_i \partial \xi_j} \right)^2 \\
4 q_2 &= |q_1|^2 + \sum_{i=1}^{3} \left| \frac{\partial p_1}{\partial \xi_i} \right|^2
\end{aligned}
$$

P: pressure, $\tau = \omega T$, $\xi = \frac{\omega}{c} x$, c : velocity of sound, γ: specific heat ratio, ε: excursion of the diaphragm

Generalized Helmholtz equation

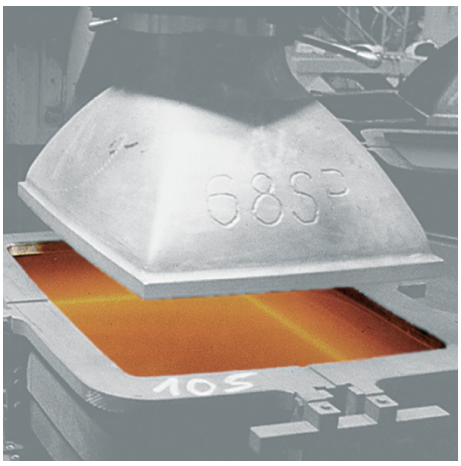
This speaker has especially been designed in order to avoid distortions during high performance. The simulation shows that, due to the special embedding of the bass reflex tube (middle below), the first and second derivatives of the pressure do not become too large at any point. According to the equation opposite, the essential source of the distortions is eliminated.



Radiative Transfer

The research work with respect to radiative transfer at the Fraunhofer ITWM originated in one concrete application problem of the company Schott: the cooling of glass. Glass properties like the refraction index, as well as the quality of the glass, decisively depend on this cooling process. In the case of semitransparent materials, the coupling of heat conduction and thermal radiation leads to a complex problem: the heat transfer equation must be extended by a flux term describing the radiation. Besides, the temperature depends on time and space, and the radiation additionally depends on direction and frequency, so that in the end we have a seven-dimensional system of partial integro-differential equations. In the past, numerical methods have been developed which allow an efficient simulation of realistic problems.

In the last year, the research work in the field of radiation was extended. On the one hand, radiation was coupled with problems of parameter identification and optimal control. Subjects were the reconstruction of the temperature-dependent coefficient of heat transfer during the cooling process of glass, and the optimal control of a furnace during the annealing process. On the other hand, the research activities were extended to other materials and applications. The interdisciplinary project "RadioPlan" of a program of the Federal Ministry of Education and Research (BMBF) "Leben und Arbeiten in einer vernetzten Welt" deals with the intensity modulated radiation therapy planning (see also the reports of the departments OPTIMIZATION and MODELS AND ALGORITHMS IN IMAGE PROCESSING on p. 88 and p. 63). One of the tasks here is the development of an efficient module for the dose computation. Simultaneously, within a project of the "Foundation of Rhineland-Palatinate for Innovation" effective numerical methods for other strongly scattering media are developed, e. g., opaque glasses or ceramics.



Hot glass in the mold has been pressed to the form of a TV screen and is now in the cooling phase.
© Schott Glas Mainz

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Standing (from left): Dr. Dietmar Hietel, Dr. Raimund Wegener, Dr. Robert Feßler, Dr. Jörg Kuhnert, Dipl.-Math. Rainer Keck, Dipl.-Math. Christian Schick, Dr. Hartmut Hensel, Dr. Jan Mohring
Sitting: Dipl.-Ing. Sergej Antonov, Dr. Sudarshan Tiwari, Dipl.-Math. Peter Schlosser
Not in photograph: Dr. Marco Günther, Dr. Norbert Siedow, Dipl.-Math. Markus von Nida

Flow in Complex Structures

The department Flow in Complex Structures develops mathematical models and adequate numerical methods, mainly for the simulation and optimization of flow dynamical processes in complex applications. Last year's research areas

- simulation of porous materials,
- virtual material design,
- filling and casting processes,
- flood and risk management, and
- high performance computing and visualization

could be expanded specifically in the year 2001 by acquiring the necessary competences and extended to new applications, so that in the following year, the department will grow considerably.

A high demand for simulation and design tools can be observed in filter industry. Here, the combination of the competences in the fields of "Simulation of Porous Media" and "Virtual Material Design" results in decisive advantages on the market. Moreover, the research activities in the field of "Virtual Material Design" were increased in order to extend the basic technology of microstructure simulation to additional material classes and important material properties.

The code ParPac, which is based on the Lattice-Boltzmann method, is continuously further developed and has become indispensable for the computation of occurring flows in three-dimensional complex geometries.

The simulation of casting processes is not only a tool for the design of casting processes, but also for the prediction of local properties of molded parts, thus allowing a virtual examination of the molded parts of a component. Actual problems are the fiber orientation during injection molding of plastic parts, as well as the analysis of stresses and distortions.

A concrete application of the method of flood and risk management is the analysis of extremely strong rainfalls occurring during the last few years in Kaiserslautern. The expansion of applications to the field of emergency management has been reinforced by the catastrophe on September 11, 2001.

The research area "Parallel Computing and Visualization" is quickly becoming an independent research area of the institute exceeding the exclusive applications within the department. This year, we have started to work on the foundation of a Fraunhofer Grid for the common use of software and hardware resources within the Fraunhofer-Gesellschaft (cf. p. 99).

Simulation of Porous Materials

Porous materials and their applications

Materials where porosity represents a key for the determination of application-relevant properties are frequently used in many technical applications. Pore size and pore size distribution, as well as the shape and volume of pores are decisive parameters for surface and deep-bed filters. Open materials like fleeces, foams, and knit fabrics, offer interior surfaces for the exchange of substances and heat with media flowing through these materials, e. g., in catalyst carriers. However, the selection and design of appropriate porous materials in technical applications up to now is mainly based on experience and experimental tests. With our competences in the fields of microstructure simulations (see section "Virtual Material Design") and macroscopic modeling of porous media, we develop software tools which support companies with respect to the selection of materials and product design.

Mathematical models and methods

Due to the complexity of flows through porous media, different physical models and mathematical methods are applied for the simulation. Usually, the modeling of flows in porous media is based on Darcy's law. However, in specific cases, the Brinkmann model is also used (e. g., in the case of high porosity or if the effects of solid boundaries must be accounted for). Currently, algorithms for the Forchheimer extension of Darcy's law (for the case of high velocity flows) are developed. Flows of Newtonian and non-Newtonian fluids (polymers, heavy oils, etc.) can also be simulated, and the deformation of the porous media and the interaction with the flow can additionally be accounted for. Based on the experience of many years in the fields of saturated (single-phase flow) and unsaturated flows (two-phase flow, constant pressure in the second phase), the research activities have recently also been extended

Detailed simulation of flows through filters

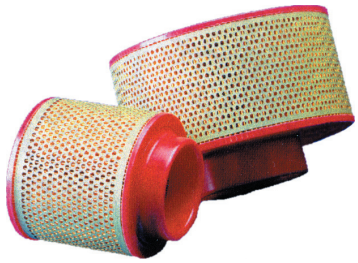
to the field of multiphase flows. Special methods are developed for the simulation of coupled flows in purely liquid phases and in porous media. In several cases of complex geometries, modern methods like the fictitious domain or the level set method are applied. Multigrid and adaptive refinement methods are used in order to accelerate computations.

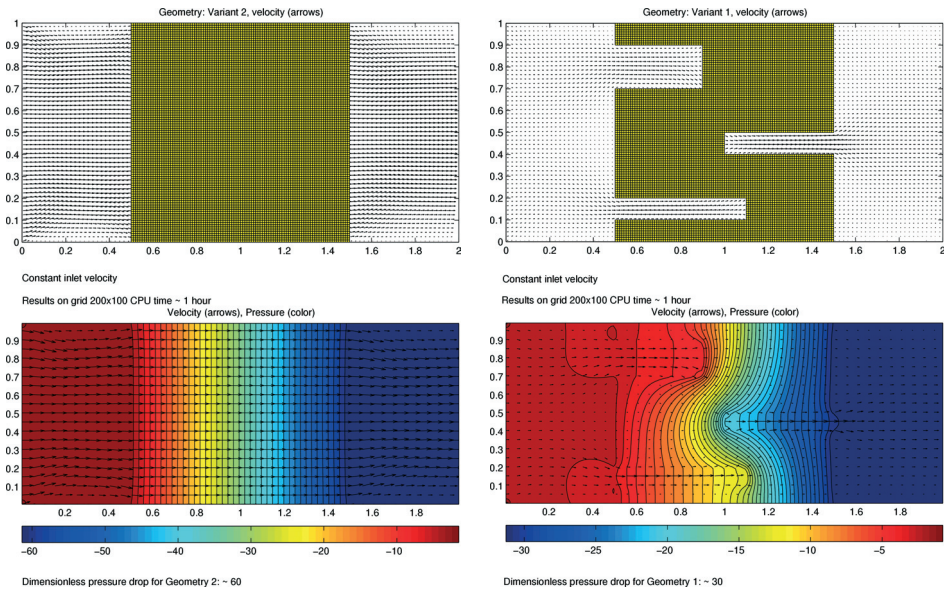
The following examples are supposed to give an impression about the way how the competences of the research group are applied to specific problems in industry and research.

The projects of the research group "Simulation of Porous Materials" are carried out by Dipl.-Math. Stefan Rief (phone: 06 31/3 03-18 13), Dr. Oleg Iliev, and Dr. Aivars Zemitis.

Filters are extensively used in modern industry. Several filters work on a purely mechanical basis (e. g., particle filters for oil), whereas others involve chemical or biological reactions (e. g., catalytic filters in cars, filters for drinking water, etc.). In any case, the filter performance strongly depends on the character of the flow through the filter. At the Fraunhofer ITWM, models and algorithms for the simulation of such flows are developed. Special software solutions are currently developed for filter manufacturing companies.

In the case of purging exhaust gases of modern cars, the gas flows through catalytic active metal porous media. In cooperation with the Fraunhofer IFAM in Dresden, the shape of these catalytic media is optimized at the Fraunhofer ITWM. The objective is a shape design which preserves the purging performance, simultaneously minimizing the pressure drop. At the IFAM, the respective laboratory experiments are performed, whereas the ITWM carries out the numerical simulation, developing numerical algorithms and software for the computation of the velocity and pressure fields within the tube (i. e. in front of, within, and behind the catalytic porous medium).





In a disk-shaped filter, we want to minimize the pressure loss without decreasing the filter quality. Therefore, the shape is changed: at the inlet and outlet of the porous disk, small holes are produced whose location, number, and size can be varied. The images above show the shape, those below the velocity (indicated by the length of the arrows) and the pressure distribution (color scale) in the filter, before (left) and after (right) the optimization.

Modeling of RTM (Rasin Transfer Molding)

The objective of the simulation is the infiltration of the liquid polymer phase into the solid matrix of the pre-mold. Here, accounting for the polymer rheology is decisively important. Due to the strong nonlinear character of the governing equations, the flow simulation of a non-Newtonian liquid phase through porous media is very complicated. Fast algorithms for the solution of this nonlinear system are currently developed at the ITWM.

Modeling of multiphase flows in porous media

Efficient algorithms for the modeling of such flows are usually based on a transformation of nonlinear partial differential equations into a more convenient form, e. g., by the multiphase mixture model (MMM) or the global pressure model (GPM). The Fraunhofer ITWM develops numerical algorithms and software for the solution of the transformed system of equations. After a testing and validation phase, these methods are supposed to be applied for the simulation of industrial problems.

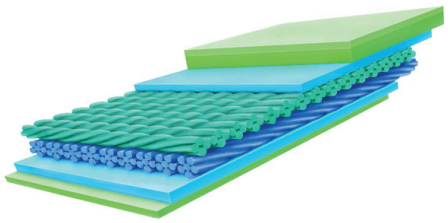
Simulation of the forming and dewatering processes in modern paper machines

Being up to eleven meters wide and 200 meters long, the paper machine with its enormous dimensions is in the center of paper production. Its components are the forming section, pressing section, and drying section, where the ready paper is produced from a paper fiber suspension. The decisive processes are the forming of the paper layer, which mainly takes place in the forming section, and the efficient drying of the fiber suspension.

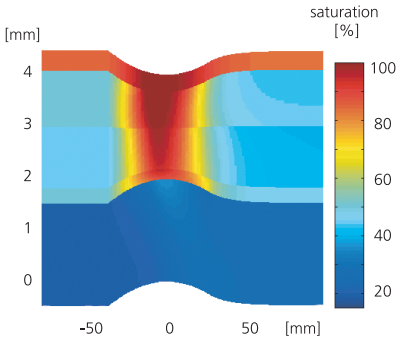
Up to now, the Fraunhofer ITWM has examined the dewatering process in the pressing section for the company Thomas Josef Heimbach GmbH & Co. Models for the elastic and flow dynamical processes have been developed. A computer program developed here allows for the computation of the dewatering performance of different press and felt configurations if the decisive process parameters are used as input data. Thus, development costs are reduced on the one hand, and on the other hand, due to the short computation time, a specific felt optimization can also be achieved by intensive parameter studies. This method offers a clear competitive advantage on the search for the "ideal felt".

Further developments

For a better adaptation of further developments to the needs and requirements of companies, we have carried out a survey together with the Fraunhofer Institutes IZFP, ISE, and IKTS. Enterprises from automobile and textile industry, the environmental and energy sector, ceramics and construction industry were questioned. It clearly came out that the most important field of applications refers to filters. Therefore, we will increase our future research with respect to applications of our methods in the field of "filtration".



Scheme of the layers of a modern dewatering felt (© Heimbach)



Simulation of a roll press slot: we can see the fluid distribution (saturation) in felt layers and paper (top).

Virtual Material Design

Modern materials and components produced from these materials are multifunctional, i. e. they meet different requirements at the same time. Flow resistance, capillary pressure, filter effects (droplets and particles), acoustic sound absorption, thermal conductivity and thermal insulation, stiffness, firmness, and durability are all supposed to be accounted for simultaneously. By "Virtual Material Design" VMB, as many of these properties as possible are simulated and optimized for a material, considering their dependances.

The ITWM is able to model the different physical processes, resulting in a coupled simulation. Modern mathematical methods, such as homogenization, Lattice-Boltzmann method, boundary element and level set methods are further developed and applied in industrial projects. Besides, the computer models require the handling of very large amounts of data, resulting from the simulation of existing materials and from models of materials. Thus, resources like parallel computers or grid computing are necessary. For a better understanding, processes must be visualized and results transformed into parameters comprehensible for the customers, or into process simulations for a further use.

In order to adapt the research to the requirements of industry, the ITWM has conducted a market analysis with a survey and a workshop. From 121 companies from different industrial branches (automobile, textile, environment, energy, etc.), only a few have been using simulations for material design up to now, but two thirds intend to do so in the future. The largest potential on the market refers to flow and structure mechanical properties. Therefore, the future research with respect to VMD at the ITWM will concentrate here.

VMD is already applied for the improvement of sound absorption of staple fiber fleeces, the variation of wetting properties of oil filters, the examination of firmness and particle filter properties of ceramic foams, and the conduction of parameter studies with respect to layered materials, different material densities, different microgeometries, and effective stiffness.

The field of competence "Virtual Material Design" is represented by Andreas Wiegmann, PhD (phone: 06 31/3 03-18 24), PD Dr. Heiko Andrä, PD Dr. Arnulf Latz, and Dr. Doris Reinel-Bitzer.

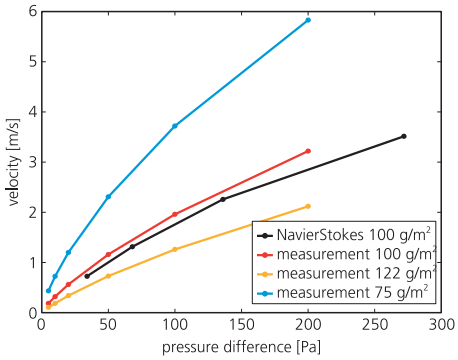
Thermal conductivity of glass wool

New regulations for thermal insulation require the production of continuously improved insulation materials. Commissioned by the company Pfleiderer AG, a study of the thermal conductivity of different glass wools was conducted with the objective of minimizing the material costs. Glass wools differ with respect to their distributions of fiber radii, the proportion of glass, and the fiber orientation. Flow simulations in microscopic models were applied in order to compute the permeability of the glass wools. Based on experimental measurement data, a relation between thermal conductivity and permeability was determined. Thus, features of the glass wool could be defined which lead to good insulation properties. Currently, the production process is varied in such a way that glass wools with improved properties can be produced. Process simulations are especially helpful here.

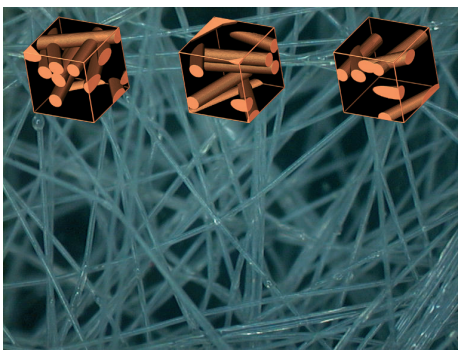
Within a project supported by the "Foundation Rhineland-Palatinate for Innovation", thermal conductivities in microstructures are also computed directly.

Flow resistance of fleeces

The average flow of air through three very thin fleeces of different weights per unit area was measured and simulated for different air pressure differences. The simulation of the fleeces accounts for averaged parameters like porosity, fiber radii, and distribution of fiber directions. However, the exact position of the fibers is chosen at random, so that in the simulation, variations of the microscopic fleece geometry are possible, as it is the case in the real fleece (see figure below). The black curve in the figure shows the computation results for the mean weight per unit area. The results of the simulated fleece geometry, which were achieved without any knowledge about the measurement results, coincide very well with the measurements of the real microstructure (comparison of the red and black curves).



Simulation of the flow resistance of fleeces: the black curve shows the results of the computations for the mean weight per unit area.



Microscopic image of a thin spinning fiber fleece of the company Freudenberg and variations of the fleece geometry

Integrated product policy (IPP) for compression molded parts in automobile industry

Considering the entire life cycle of a product from its production and its phase of use up to its disposal, IPP concentrates on the weaknesses of already existing products: during the development of a product, not only the requirements of long-lasting functionality are met, the effects on the environment during the entire life of the product are additionally accounted for. IPP is intended to continuously improve the product quality with respect to the effects on human beings and environment during the entire life of a product.

The project is supported by the Bavarian State Ministry for Regional Development and Environmental Affairs.

IPP application

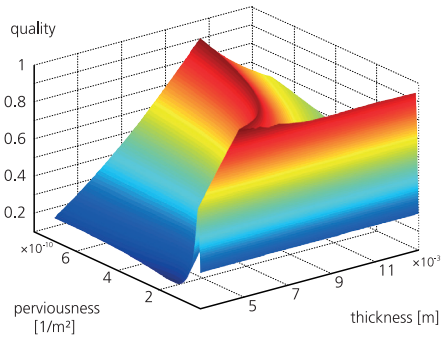
The directive of the EU on end-of life vehicles requires that in the product chain of recycling, at least 85 percentage determined on the basis of weight must be recycled. However, the car's acoustic trim is currently produced from composite materials whose components are difficult to separate. Providing computer simulations which allow the virtual optimization of many variations of a material, the Fraunhofer ITWM enables producers to act according to IPP by developing compression molded acoustic trim consisting of pure materials which can be recycled.

Acoustic design

The structure of fleece materials for compression molded parts is accounted for in a computer model by stochastic fiber parameters (density, radius, orientation). First, the flow resistance of these structures is computed with the ParPac software (see p. 44). Afterwards, the AKUDICT software determines the acoustic properties of the fleeces, based on which the statistical energy analysis simulates the acoustic properties of the compression molded part. Vice versa, these three simulation steps are used for acoustic design: based on the desired acoustics of the passenger compartment, the structural properties of the fleeces are computed.

Advantage

Computer-based simulation methods avoid long development periods and the costly construction of prototypes. Acoustics is improved, which results in a more pleasant driving experience. The cycle raw material - fiber - compression molded part - raw material is closed by the application of pure materials. The weight reduction reduces fuel consumption.



Quality of the acoustic absorption of staple fiber fleeces if thickness and flow resistance are varied: the value 1 means that the computed absorption exactly corresponds to the desired absorption; smaller values represent less correspondence.

The companies Sandler and Faurecia, suppliers of the automobile industry, are also partners of the IPP project. The left image shows a production line for staple fiber fleeces at the company Sandler, the right image represents a roller-type test stand of Faurecia, where the noise level of passing cars is measured.

ParPac: parallel particle codes for industrial applications

ParPac is based on a multi-relaxation scheme (GLB) derived from the Lattice-Boltzmann (LB) equation. The idea of this method is the solution of macroscopic equations, such as the Navier-Stokes equations, by the simulation of simplified particle kinetics. The method is specified by the selection of a set of discrete particle velocities, an equilibrium distribution, and a collision operator. The macroscopic transport coefficients are determined by the eigenvalues of the collision operator.

The basic module of ParPac contains a completely parallelized 3D Stokes / Navier-Stokes solver for incompressible / weakly compressible flows. Special collision operators allow for an almost exact localization of the boundaries, so that even complex 3D geometries (see "Virtual Material Design") can be dealt with efficiently. In the case of stationary flows, the method quickly relaxes. An improved "immiscible Lattice-Boltzmann algorithm" is used for the two-phase module in order to reduce previously occurring errors at the phase boundaries. In the case of a large phase disparity, the flow is simulated as a single-phase flow with a free surface. The recently developed method, which is patent pending, is very robust with respect to complicated surface topologies because the boundary area is not constructed geometrically, but results from the population distributions instead. An application example are filling simulations with non-Newtonian fluids (e. g., plastics). Following the idea of stabilizing methods, all the components of the stress tensor are computed locally from the non-equilibrium distribution of the populations. The temperature balance can also be accounted for by the integration of an additional module.

Current developments

The development of ParPac with respect to algorithms and software is carried on in the framework of a DFG project ("The generalized LB method for free boundary value problems and multiphase flows") and a BMBF project ("Adaptive grid control for LB methods for the simulation of filling processes in casting technology", in cooperation with Prof. Dörfler, University of Karlsruhe). During a visit of several months, Prof. Dominique d'Humières (ENS, Paris) supported our research activities in the field of accuracy and stability analysis. The pure GLB algorithm is of second order, therefore the method considerably loses accuracy due to the standard reflection boundary conditions which are of first order. The new multi-reflection boundary conditions offer an alternative for the computation of bound-

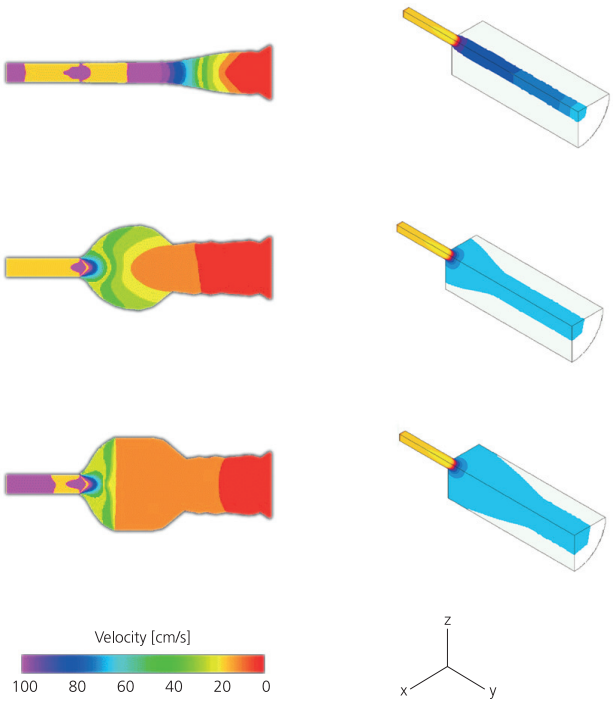
ary conditions which are not adapted to the grid, inclined, or curvilinear: they are not discretized stepwise any longer, but solved smoothly instead. Moving geometries are also realized in ParPac by this method. The simulation of moving particles (suspensions) represents an important application example. In many cases, heterogeneous geometric structures require a local grid adaptation in order to remain below given error tolerances. Using simple flow benchmarks, we examine how grids of different mesh sizes can be coupled.

Due to the various extensions of ParPac, a revision and adaptation of the applied data structures has become necessary. Additionally, a special interface is supposed to enable the user to control the computations during the run time and to integrate a direct visualization.

Industrial applications

Especially 3D flow problems in complex geometries can be computed with ParPac. Microstructure simulation (see "Virtual Material Design") is an ideal example. Additionally, two-phase flows with distinct capillary effects and strongly varying dynamic viscosity can be computed. A module for the computation of free surfaces allows filling simulations for very different fluids, also enabling the user to simulate filling processes of non-Newtonian fluids, such as viscoplastic alloys and plastics. The temperature balance can also be accounted for by the integration of an additional solver. The simulation of the cooling process of spinning filaments in pressure chambers is an example for the possibility of fluid-structure interaction with ParPac.

The ParPac code is further developed by Dr. Irina Ginzburg (phone: 06 31/ 3 03-18 16), Dr. Peter Klein, and Dr. Doris Reinel-Bitzer.



A filling simulation of a viscoplastic fluid in 2D (left) – the colors indicate the velocity in [cm/s]: red 0-15, yellow 15-25, green 25-55, blue 55-90. We can clearly see the formation of a "velocity bubble" in the upper section before the mold is completely filled. The same simulation in 3D (right) – velocity scale [cm/s]: blue 0-32 , red 54-75, yellow > 107.

Simulation of Filling and Casting Processes

The research area "Filling and Casting Processes" comprises a wide range of activities referring to the simulation of processes in the field of iron casting and injection molding of plastics.

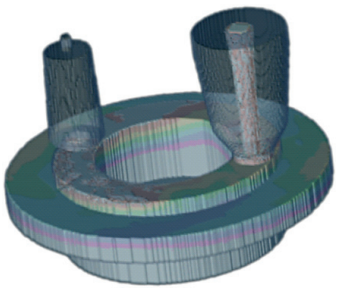
In the year 2001, the field of casting processes was again dominated by the cooperation with the company HegerGuss. The standard "virtual casting" on the computer comprises the computation of the mold filling process and of the following solidification of the molded part. Meanwhile, these simulations are routine at HegerGuss. As an experienced user of MAGMASOFT, the ITWM supports the company HegerGuss by training courses for the staff, as well as by consultations with respect to special application problems of the simulation software for the solution of complex problems of casting technology. For 2002, the plans of the project schedule the extension of simulation activities towards the integration of stress simulation as an element of the process chain "extended casting simulation". One objective is the computation of residual stresses and of the deformation of molded parts, ensuing the simulation of solidification. These computations are carried out with the parallelized version of MAGMASOFT on a PC cluster, because the considered molded parts principally are so-called "structural parts". As another objective, HegerGuss and the ITWM together deal with the subject of "biodesign" of molded parts in the framework of a publicly funded research project. The application of mathematical methods for structural optimization allows the construction of machine components in such a way that those parts of the component which are subject to higher loads are reinforced,

whereas in other areas where the load is decreasing, less material is used. On the computer, a shape of the component is developed where stresses are distributed as equally as possible. In such a way, components can be designed which are not only characterized by high stiffness, but also by the lowest possible weight. The combination of solidification simulation and stress computation with other software tools is also an important part of the common research project.

The common activities of the ITWM and the company MAGMA with respect to injection molding of plastics belong to the field of computing the fiber orientation for short-fiber reinforced thermoplastics. The project planning for the following year is focused on the extension of the modeling in order to improve the prediction of the mechanical properties of injection molded parts made of short-fiber reinforced thermoplastics. First, we will concentrate on the computation of the spatial variation of the fiber concentration during the mold filling process. The anisotropic material properties caused by the fiber orientation, as well as the spatially varying values of the fiber concentration are used as input parameters for the ensuing structural mechanical computations.

An especially interesting project resulted from the cooperation with the artist Prof. Benno Werth, Aachen (see p. 48), who also deals with the casting of bronze sculptures. The "Method of Subtractive Molding", invented by Benno Werth, allows him the design of very complex shapes. From a technical point of view, the ITWM's task in this project was the simulation and visualization of the casting process for a bronze sculpture designed by Werth. In contrast to the simulation of "conventional" casting processes, however, the shape geometry was not available in the form of CAD data. Therefore, the real shape geometry first had to be transferred to a virtual image on the computer by methods of image processing (computer tomography, digital processing and binarization of the CT data). In this virtual form, the mold filling and solidification processes of the sculpture - both remain hidden to the eyes of the observer of the real process - first were simulated and then visualized.

The projects in the field of "Simulation of Filling and Casting Processes" are dealt with by Dr. Joachim Linn (phone: 06 31/3 03-18 23), PD Dr. Heiko Andrä, Dr. Irina Ginzburg, and Dr. Oleg Iliev.



Filling simulation of the bearing housing of a flange (filling level)

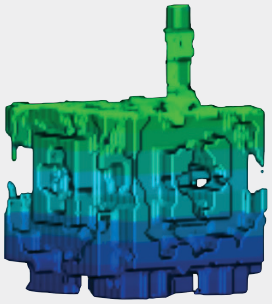
Benno Werth: My casting method

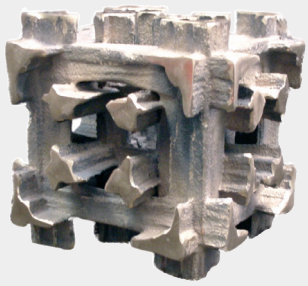
"Strictly speaking, according to the two known methods of sand molding and lost wax casting, the casting of a metal sculpture is not only a question of the designer's intellect, but also of the technical feasibility. Up to now, metal casting has only been possible if based on a model. Statics and structure of the model material (gypsum, wax) have their individual properties and restrict the natural moldability of the metal, which offers a much wider range of possibilities. Consequently, I have developed the method of negative respectively subtractive molding. Such a direct casting requires the conception and cutting of a sculpture exclusively as a negative mold.

In general, the negative mold will consist of several parts. Already here, it is possible to compose the individual parts according to a compositional plan. When the complete casting block is assembled from the different parts, the result must be a continuity of the branches of casting channels. The casting channel and the air flow channels form a communicating tube.

The method of negative molding does not compete with already existing techniques, since they have their own tasks. However, it extends the supply of shapes given by the nature of the metal itself by doing without a model, and offers the possibility of shapes and undercuts of arbitrary complexity, which are impossible to reach with other casting methods. It goes without saying that a second casting of sculptures designed in such a way is out of question."

Slightly abbreviated from: Benno Werth, "Ein neues Gussverfahren", das kunstwerk, 6 – XVIII, December 1964, p. 36





The artist Benno Werth has developed the "Method of Subtractive Molding" in order to create complex bronze sculptures. The left figure shows the simulation of the casting process computed at the ITWM, and the right figure the completed bronze sculpture.

Flood and Risk Management

In the case of extremely heavy rainfall, the drainage systems of urban areas often cannot cope with the large amounts of water. The situation is additionally aggravated by the high water of nearby rivers, and the consequences are large damages of buildings and of the city infrastructure. Here, a series of problems arises which are the subject of examinations in the field of flood and risk management:

- utilization and overflow of drainage systems, including possible flow paths on the surface,
- damage quantity and quality, e. g., depending on the water level,
- computational proof of official regulations (European general water directive EN 752),
- planning scenarios for the connection of new building sites to the drainage system and for the renewal of entire partial systems,
- problems of the insurance industry, as well as
- emergency management.

Flow across curbstones

In the framework of a PhD-thesis, water flows across edges and out of gully holes are modeled. The application of the usual shallow water equations, where the vertical velocity components are assumed to be negligible, is very problematic. In extreme cases, wrong results can lead to wrong statements: a cellar is inundated or not. Currently, promising modification approaches of the shallow water equations are developed and tested.

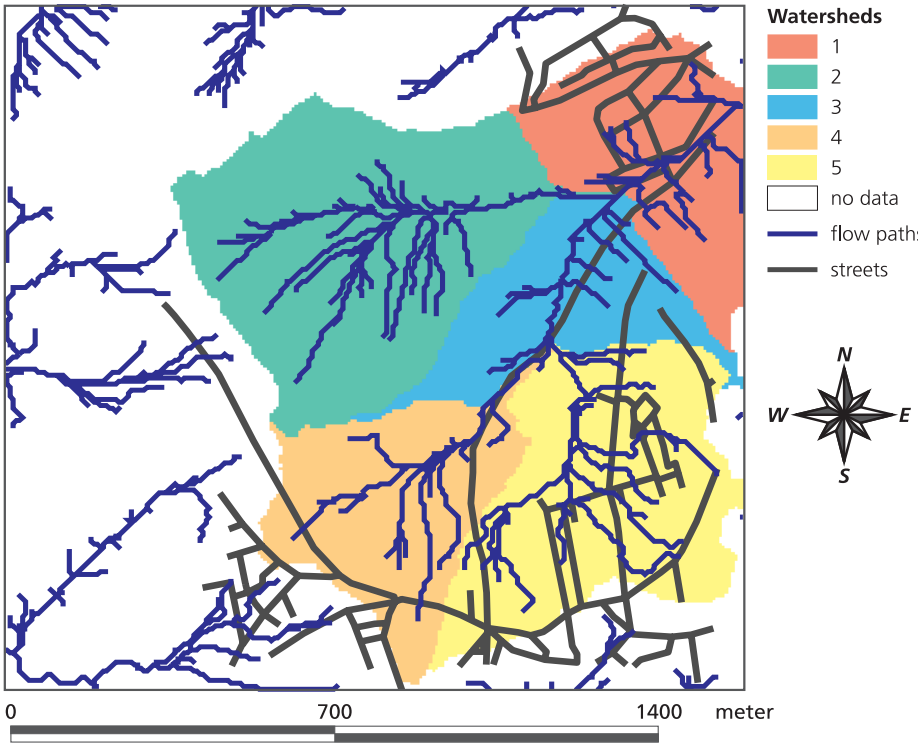
Inundation situations in cities

Within the EUREKA project Σ!2255 RisUrSim, a GIS-based simulation and planning tool is developed by an interdisciplinary and international consortium, headed by the ITWM and consisting of computer scientists, urban water management experts, local authorities, (re)insurance companies, and mathematicians in Norway and Germany. The flow on the surface is coupled with the events in the channel system. Different urban areas are tested. A further part of the development is an ensuing post-processing, which deals with the damage situation in the case of inundations.

Hydrologic events on the surface

In cooperation with the city of Kaiserslautern, this problem area is completed by the analysis of the disastrous high water situation in one part of the city in the year 2000. Hydrologic models of the surface are also accounted for with respect to the balancing of the water budget in urban boundary areas.

The research projects in the field of Flood and Risk Management are coordinated by Dr. Klaus-Peter Nieschulz (phone: 06 31/3 03-18 18).



Digital base of the map:
Amt für Bodenmanagement und Stadtvermessung, City of Kaiserslautern

The map shows an area of approximately 120 hectares of the city of Kaiserslautern. This area is divided into five subwatersheds corresponding to different colors. The figure represents flow paths in the individual subwatersheds. The components of the map were computed with the Geographic Information System *(GIS) ArcView®* and additional tools.

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Standing (from left): Dipl.-Ing. Iuliana Matei, M.Sc. Ivatz Dakov, Dr.-Ing. Carsten Lojewski, Dr. Dimitar Stoyanov, PD Dr. Heiko Andrä, M.Sc. Vita Rutka, Dr. Klaus-Peter Nieschulz, Dr. Peter Klein, Dr. Andreas Wiegmann, M.Sc. Vsevelod Laptev, PD Dr. Arnulf Latz, Dr.-Ing. Joachim Linn, Dipl.-Math. Stefan Rief, Dipl.-Math. Michael Hilden, Dipl.-Phys. Martin Rheinländer, Dr. Konrad Steiner, Dr. Oleg Iliev **Sitting:** Dipl.-Math. Ashok Kumar Vaikuntam, Dr. Doris Reinel-Bitzer, Dr. Irina Ginzburg
Not on picture: Dipl.-Math. Dirk Kehrwald, Dr. Aivars Zemitis


DeLonghi

Models and Algorithms in Image Processing

The competences of the department MODELS AND ALGORITHMS IN IMAGE PROCESSING refer to the following areas:

- surface inspection,
- 3D image analysis and modeling of microstructures,
- signal analysis for railway systems,
- data compression by wavelet methods,
- cryptography

All the research areas are focused on the development of complex algorithms and their implementation into an efficient code for standard hardware (PC cluster), partially also fulfilling real time conditions.

The department has a wide range of experience in the field of surface inspection, especially with respect to the development of algorithms and systems for the control and evaluation of textured surfaces, such as paper, textiles, nonwoven fabrics, wood. The Fraunhofer ITWM is specialized on problem solutions which are generally complicated and must fulfill special requirements, which is why they are not available as serial systems of commercial software producers.

3D image analysis is becoming increasingly important, because the technical possibilities of creating high-resolution three-dimensional images of very different materials are developing very fast. The research at the Fraunhofer ITWM concentrates on the determination of geometric properties of material microstructures by methods of stochastic geometry. This is the basis for the development of 3D models of these materials which reflect the geometric structures very well, thus simplifying or even allowing for the first time computations and simulations.

Further new developments are worked on in the field of elastic matching of medical data within the project RADIOPLAN.

The relatively young research area "Cryptography" is supposed to meet the increasing demand for secure data transfer.

Surface Inspection

In many cases, the quality of a product depends on the quality of its surface. A unified approach is difficult due to the variety of possible surfaces. The quality of almost every type of surface is measured individually, depending on very different properties. In the case of, e. g., paper, textiles, or metal products, possible defects occur locally, so that it makes sense to look for local deviations with respect to a global homogeneity. In the case of other products (fleeces, wood products, carpets), however, properties are considered that characterize a larger section of the sample or the entire sample.

Very often, the tasks of surface inspection are still carried out by especially trained controlers. Frequently, by this method only random samples can be examined, mostly according to criteria that are not subject to objectivization. A complete online product control and the guarantee of a constant quality are impossible.

The Fraunhofer ITWM has a wide range of experience with respect to the development of algorithms for automatic surface control. A number of tools and system components are ready for use which can easily be adapted to almost every problem. In the following, some of the applied mathematical methods and solutions based on these methods will be presented in detail.

In the field of Surface Inspection, the colleagues are: Dipl.-Inform. Markus Rauhut (phone: 06 31/3 03-18 72), Dipl.-Math. Mark Maasland MTD, and Dipl.-Phys. Andreas Jablonski.

Examples for typical surface defects: inhomogeneities in a fleece, weaving defect in a fabric, and scratches on a coated paper

Textured, colored surfaces

If finest shades of the color of structured surfaces are to be evaluated, human controllers and classical methods for the determination of colors cannot cope with the problem. The color differences determined visually can hardly be reproduced because they strongly depend on the observer and the surroundings. Color measurement tools cannot be applied since they work on the basis of an unstructured homogeneous surface.

Particularly for these tasks, the software FOQUS has been developed at the Fraunhofer ITWM. The system is based on a standard CCD color camera and allows the objective detection of the fine color differences of structured surfaces. The RGB pixel values provided by the camera are transformed into the HSI space. This nonlinear transformation separates information about color and brightness. The result is a simple compensation of brightness variations.

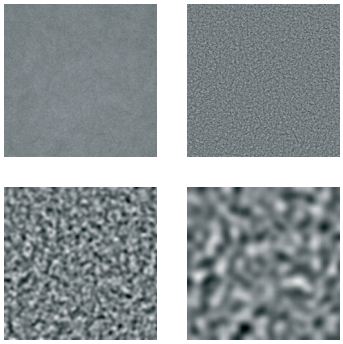
Based on the HSI images, features are computed which describe the structure and color properties of the actual sample. The system is supposed to decide according to similar criteria as the human controller, therefore it is presented presorted examples in the training phase. Based on the feature values of these reference samples, optimal separating planes are computed in the feature space, which allow a correct assignment of new, unknown samples.

The figure represents a typical application of the system FOQUS: above the unsorted random sample, below the same sample after the sorting by FOQUS.

Fleece homogeneity

During fleece production, the so-called cloudiness is used as an indirect measure for the evaluation of the fleece firmness. It is a term which is difficult to determine quantitatively, thus it is only available to experts. With a multiscale approach, the ITWM has succeeded in developing an algorithm for a quantitative evaluation of the fleece homogeneity, which represents the core of VQC, a tool for the quality evaluation of fleeces, available at the ITWM.

The original image is subjected to a multiscale analysis according to the Laplace pyramid. This method suggests itself, since the fleece homogeneity is a multiscale phenomenon by nature. As a measure of inhomogeneity, the variance of the images is computed on each scale. The variances of the individual scales are added up to a homogeneity index in a weighted sum. The scale gradations can be customized, so that an adaptation to different types of fabric is possible.



Fleece (from above, left to below, right): original and structures on three different scales

Inspection of paper surfaces

In the paper producing industry, the quality control is also frequently still performed by especially trained personnel. This method of control is laborious and time-consuming.

At the Fraunhofer ITWM, a system for the automatic paper inspection has been developed. The inspection system SPOT does not only improve the quality of the previously manual inspection by objective criteria, it also controls the paper at high velocity. High velocity is important because an automatic inspection system is supposed to be directly integrated into the production process without slowing down the production.

In the center of the system is a fast image processing algorithm (approximately 70 ms) which detects and simultaneously classifies defects, e. g., spots and scratches, on the homogeneous paper surface. Input data of the algorithm are digital images of the paper surface, provided by cameras installed above the conveyor belt for the paper sheets.

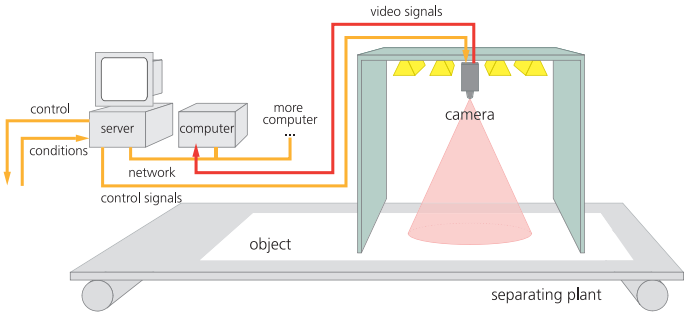
Image processing

As a first step of the image processing algorithm, the camera image is reduced to the relevant region, i. e. the section of the image showing only the paper sheet. After this "recognition of boundaries", defects are detected in the image and marked by so-called ROIs (Regions of Interest). On the basis of the features provided by the ROIs, the algorithm classifies the defects. Only this step determines whether the detected defect is a point-like defect or a spot etc.

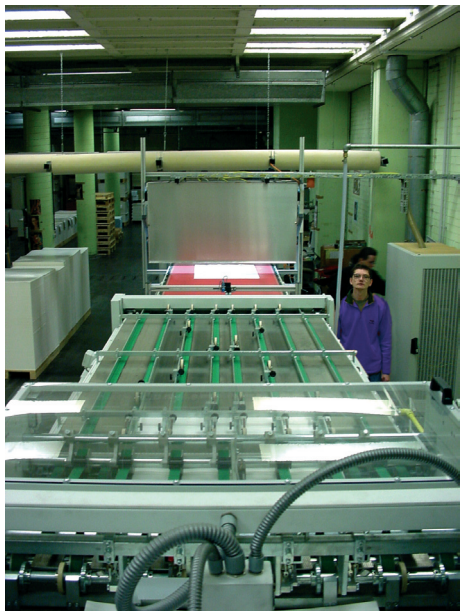
System setup

The SPOT system is directly integrated into a paper sorting machine. Above the conveyor belt, several cameras are installed which observe the entire width of the paper sheets. Each of these cameras is connected to one of the clients of the SPOT system. These clients run the image processing algorithms. Each client consists of a double processor system where several image algorithms run simultaneously. This parallelization is finally responsible for the high performance of the SPOT system.

A central server collects the results of the clients and notifies the sorting machine whether a sheet is "good" or "bad". Moreover, all the occurring defects are collected by the server, so that an overall statistics can be provided at the end of an inspection cycle.



The left figure shows the structure of the inspection system. The central server (SPOT server) controls the entire system and the image processing clients, where the acquired images are processed. On the right hand side, we can see the SPOT system applied by the paper producing company Hoffmann and Engelmann.



Inspection of unpainted free surface parts

During the production process with free surface parts, surface defects cannot be avoided. In order to reduce refinishing in the painting processes and to guarantee a constant quality level, it is necessary to detect and correct surface defects as soon as possible.

In the project "ABIS", a system has been developed which automatically detects, classifies, and marks hardly visible surface defects of raw car bodies. Thus, a propagation of these defects to the painting processes can be prevented.

The image data are transformed into depth data by demodulation, each pixel describing the distance between the respective point at the surface and the sensor. Then, the images are examined with respect to possible defects. Finally, the relevant defects are marked on the body, so that a refinishing can take place.

The task of the Fraunhofer ITWM within the project is the detailed examination of the images with respect to possible defects under difficult conditions: defects from a depth of 40 µm onwards are to be detected on uncleaned parts and at a belt velocity of up to five meters per second.

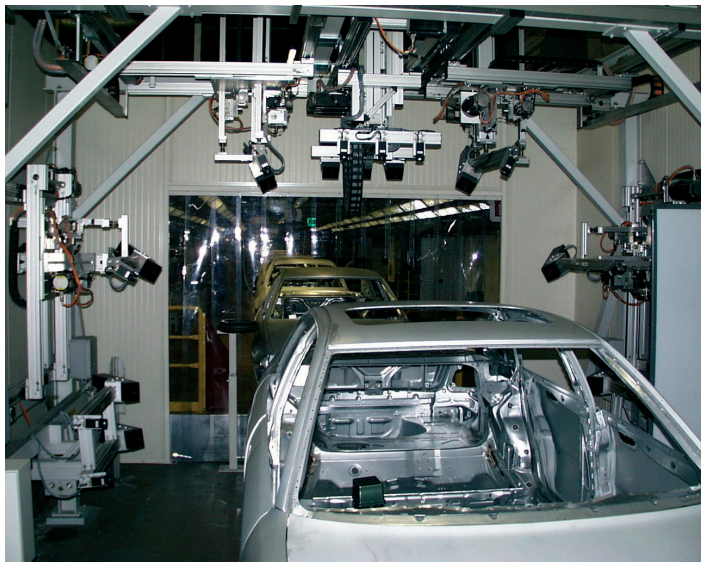
Image processing

First, by using a linear filter, the discrepancy with respect to a defect-free surface is estimated on the basis of the information provided by the images. In contrast to noise, defects such as dents or bulges correspond to relatively large values in this discrepancy image. In a second step, the so-called defect candidates are determined via smoothing and adaptive thresholding. Finally, a classificator based on Support Vector Machines (SVM) decides according to characteristic features whether these defect candidates actually are defects.

Many surface defects occur during the molding process of the free surface parts. Recently, a research project (OPAQ) funded by the BMBF has started with the objective of detecting such defects directly after the molding process.

On the painted surface, a dent can be recognized (reflection). Such dents are hardly visible on the unpainted body and can only be felt by experts. On the painted parts, such defects are easily visible, but their correction is far more costly.

The online ABIS inspection system at Audi enterprises (below): across the car, eleven cameras take 21 to 25 images each. Each image is then automatically examined with respect to surface defects.



3D Image Analysis and Modeling of Microstructures

Modern imaging methods provide an increasing number of continuously improving three-dimensional images of microstructures. Modern image acquisition techniques such as tomography with synchrotron radiation or nanotomography even allow images of materials with a low contrast or an extremely delicate structure. The three-dimensional image data represent new challenges for image processing, image analysis, and visualization.

Microstructures which are homogeneous on a macroscopic and heterogeneous on a microscopic scale, e. g., foams, ceramics, fleeces, or paper, can only be described adequately as realizations of random sets. Therefore, at the Fraunhofer ITWM the analysis of 3D images is based on the determination of geometric basic parameters for homogeneous random sets: the densities of the Minkowski functionals (volume, surface, integrals of the mean and total curvature). Efficient algorithms have been developed by the combination of methods from integral geometry and stochastic geometry, on the one hand (discrete versions of the Crofton formulas and the definition of the Euler number by von Hadwiger), and digital image processing on the other hand. From the Minkowski functionals, additional application-specific parameters can be derived, e. g., the mean length of edges per volume unit or the mean cell size for open foams, the mean specific fiber length for fiber materials or the mean number of sinter necks per particle for sintered copper.

The area of the projections and the mean numbers of intersections in planar sections in different directions in space provide information about the preferred directions and the strength of occurring anisotropies. Spectral and

covariance analyses detect periodicities and frequently occurring distances in the structure. Individual particles, pores, or inclusions (3D objects) can be isolated, and their features (volume, surface, shape factor, ...) are determined. Finally, a system for the analysis of 3D images, developed in cooperation with the company aquinto AG, is completed by a watershed algorithm, skeletonization, distance transforms, different filters for image pre-processing and cleaning, morphologic transformations, and a visualization tool.

Macroscopic material parameters like relative permeability or sound absorption depend on the microstructure of the material. In order to determine such material parameters by fluid simulation and to optimize the material virtually (cf. "Virtual Material Design", p. 41), a geometric model of the microstructure is required.

Here, 3D images of the microstructure provide the Minkowski functionals and information about the direction. According to these features, an appropriate model is adapted. If 3D images are not available, model parameters must be determined via projections or planar sections.

The microstructure of macroscopically homogeneous materials can adequately be described by models from stochastic geometry, such as Boolean models, line processes, or tessellations. The condition of macroscopic homogeneity is fulfilled through the exclusive use of stationary models, i. e. the "mean" microstructure is the same at each point in space.

In this research area are working PD Dr. Joachim Ohser (phone: 06 31/3 03-18 69) and Dr. Katja Schladitz.

In the following, three examples will be mentioned for the analysis of a microstructure, one example for analysis and modeling, and one classification algorithm based on the analysis of the geometric structure.

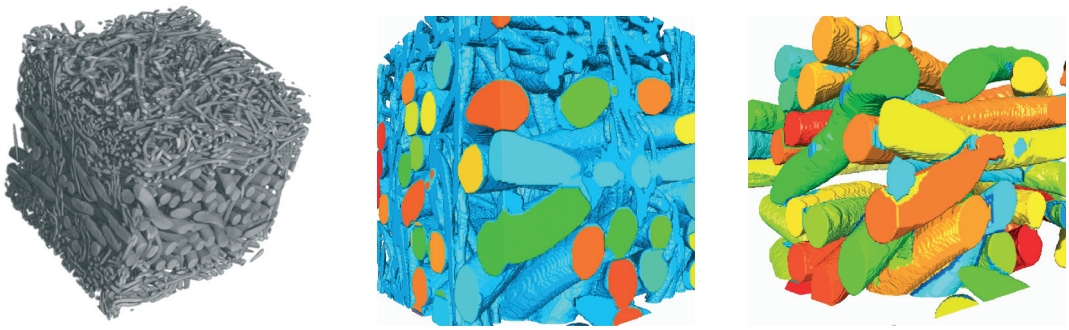
Example: refractory concrete, analysis of the corundum inclusions

Refractory concrete – consisting of the concrete matrix and inclusions of aluminium oxide (corundum) – was subjected to X-ray tomography. In order to determine the volume and shape distribution of the corundum inclusions, these were first segmented by binarization with an appropriate threshold. Afterwards, the inclusions were separated by erosion and a watershed algorithm. Then, the inclusions can be reconstructed in large parts by the intersection of the watershed image and the original. The object features of the inclusions can now be determined.

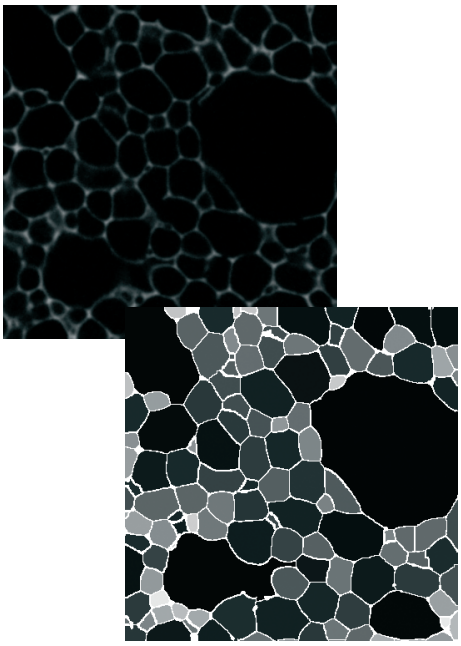
Example: polyamide felt, direction analysis

Synchrotron radiation offers new methods of tomography: with the phase contrast method, images of materials can be acquired which show a contrast too weak for classical X-ray tomography.

In order to analyze these data, the thick and thin fibers were separated first by morphologic transformations. Measurement results were: a porosity of 77 per cent, a specific fiber length of 5.2 mm^{-2}, and a mean sectional area of the fibers of 0.046 mm^2 for the thick fibers, and a porosity of 76 per cent, a specific fiber length of 12.8 mm^{-2}, and a mean sectional area of the fibers of 0.002 mm^2 for the thin fibers. The fiber direction distributions were computed for both fiber systems. Erosion, watershed algorithm, and the intersection of the watershed image and the original enable us to isolate the thick fibers and to measure them individually.



Microstructure analysis of polyamide felt: the left figure shows a section of the tomographic image. The visualization of this polyamide felt in the figure in the middle already marks the thick fibers, while the thin fibers are still visible. Finally, the right figure only shows the labeled thick fibers. © Fraunhofer IZFP



Section across the reconstructed X-ray tomographic image of a closed aluminium foam: on the left the original image, on the right the processed image with reconstructed cell walls.
© Bundesanstalt für Materialforschung und -prüfung

Example: closed aluminium foam, reconstruction of the cell walls

A closed aluminium foam was subjected to classical X-ray tomography. Due to the thin cell walls and the resulting weak contrast, a correct segmentation of the foam is impossible. However, a combination of distance transformation, morphologic transformations, and watershed algorithm allows for the reconstruction of the cells, which can then be measured individually.

Example: modeling of fleece

The optimization of acoustic or flow properties of fleeces (see also p. 38) up to now has required complex experiments. However, if these material parameters are determined in a geometric model by simulation computations, a variation of the model parameters can easily be used in order to find out how changes of the microstructure influence the desired properties. Thus, a geometric model for fiber fleeces of different pressing degrees was required. On the one hand, a series of additional information was available (porosity, fiber cross-sections), whereas, on the other hand, we had to work only with microscopic images of two-dimensional sections.

On the basis of a homogeneous Poisson process, a cylindrical model was developed which needed only one additional parameter to be determined from the image data. This anisotropy parameter describes how strongly the fibers are oriented orthogonally to the pressing direction, and can be estimated on the basis of the ratio of the numbers of fibers in sections across and along the pressing direction. The fibers cannot be counted directly by image analysis though. However, it comes out that a version of the Euler number with respect to the weight per unit area provides a good estimation.

Example: automatic classification of lamellar graphite in grey cast iron

In cooperation with the Institute for Casting Technology and several foundries and their customers, a method is developed for the classification of lamellar graphite according to structure and size, i. e. according to the proportions of A-E graphite and size classes I-VIII, prescribed by EN ISO945: 1994. The previously usual visual evaluation of the graphite structure is not only time-consuming, it is also open for subjective interpretations and therefore not reproducible. The automatic method developed at the Fraunhofer ITWM does not only make classification easier, it primarily serves objectivity. First, a comparative catalogue of section images is produced which is then classified visually by a group of experts. After the reduction of the geometric information enclosed in the images, the algorithm "learns" with this catalogue which classification of an image results from this reduced geometric information. This method is successfully applied by Rexroth Guss GmbH for the classification of A, D, and E graphite.

Monitoring for Railway Systems

The Fraunhofer ITWM has been cooperating with GE Transportation Systems Europe in Bad Dürkheim for several years now. The research is concentrated on the chassis monitoring sleeper (FÜS), for which the ITWM develops and maintains almost the entire software (except several drivers). Particular problems are the signal analysis and the system management.

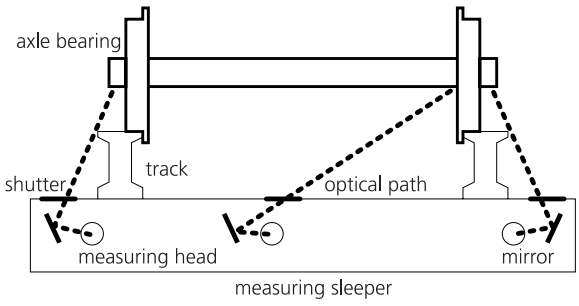
Technical background

The control of overheated axle bearings and stationary brakes on passenger and freight trains requires a remote measurement method. In the solution selected here, the temperatures are measured by sensoring the infrared profile of the passing chassis. The A/D values provided by an IR measuring head are transferred to the PC. The systems work without human control, therefore an appropriate self diagnosis system for the hardware and software must be integrated apart from the pure measuring process, as well as an exception and error handling system.

Problem

During the measuring process, a large amount of data must be registered and evaluated as fast as possible. The results of evaluation and self diagnosis are transferred to a central system which, e. g., arranges for a stop of the train at the next station.

However, it may also happen that not only the values for a wheel are sensored, but also external values (radiation from other objects) like reflections of the sun or of the brake blocks. In these cases, special methods are applied in order to find out the correct temperatures of the wheels and bearings.



The self diagnosis system works in such a way that within regular time steps, the measuring heads are recalibrated and the remaining hardware (shutters, mirrors, etc.) in the sleeper is controlled.

The development and implementation of the algorithms account for the very high requirements of reliability. The algorithms are continually refined and completed by additional modules. The flexibility of the entire system is also improved.

System environment

Apart from an industrial PC, the main server comprises special additional components and works with the operating system LINUX. The software required for the evaluation process is completed by further software packages, such as system diagnosis software, drivers, user interfaces, and server software.

The new generation of the chassis monitoring system was basically modernized with respect to the sensoring hardware and the data transfer from the sleeper to the central server. The result was a considerable extension of the software developed at the Fraunhofer ITWM, which is, however, still compatible with the old hardware.

New projects, such as the concept of an archive server, increase economic effectiveness, reliability, and availability of the systems. Measurement data and protocols from several systems are saved centrally. The information provided by these data and the application in practice over several years represent the basis for the refinement of the evaluation algorithms.

The responsible colleagues for the projects of the research group "Monitoring for Railway Systems" are Dipl.-Math. Kai Krüger (phone: 06 31/3 03-18 63) and Dipl.-Phys. Martin Braun.

Evaluation electronics: the data measured at the sleeper are processed by evaluation computers with an infrared interface located at the tracks, and transferred to central systems. Large numbers of systems of this type work in several European countries.

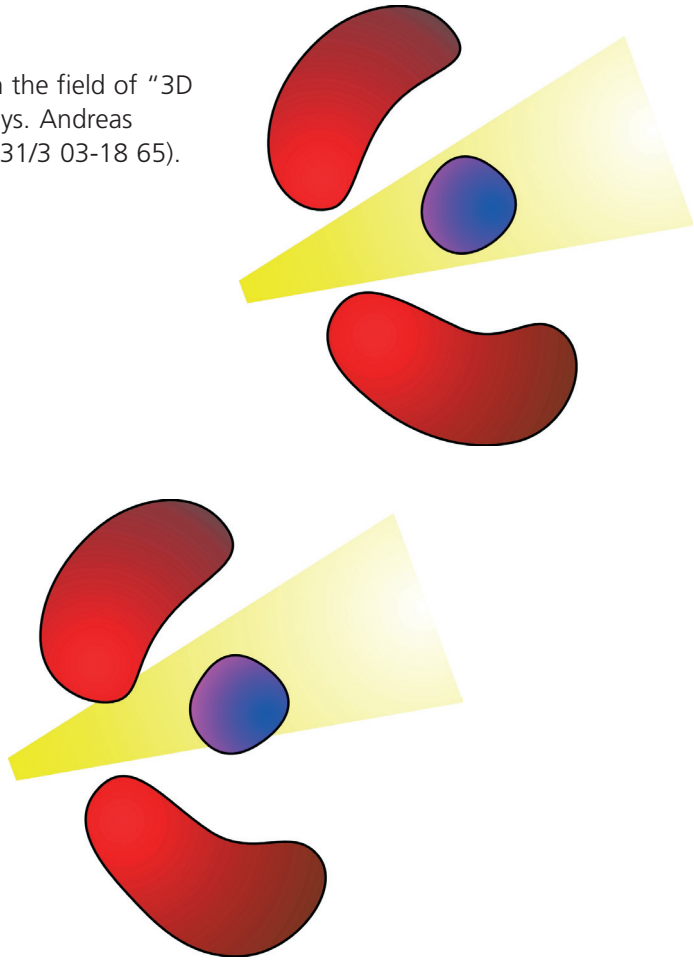
3D matching of medical images

Within the project RADIOPLAN, funded by the Federal Ministry of Education and Research (BMBF), several departments (Optimization, Models and Algorithms in Image Processing, Transport Processes) have cooperated in finding new possibilities for the optimization of therapy planning with respect to intensity modulated radiation therapy. The department Models and Algorithms in Image Processing has dealt with the problem of automatic registration and quantification of geometry variations within the target areas.

For a successful application of IMRT (Intensity Modulated Radiation Therapy, cf. p. 88), the radiation doses must be deposited very precisely in the target volumes. Hence, the geometry of the target area must be known very exactly, which is given only for a restricted number of regions of the body (head area) at the moment. If the geometry of the target area is only insufficiently known, the radiation head cannot be positioned exactly, so that neighboring healthy organs might be endangered.

The largest difficulty is that the geometry between the individual fractionations can be subject to strong variations, so that the therapy planning must be newly adapted each time. As a basis for such a matching, the motions which have taken place in the body must be identified first. The subject of the study was the question whether and how such motions can be determined by volume images. Approaches based on the optical flow equation appear to be particularly promising, because here, the existence of a unique solution can be proved under certain conditions. However, the standard optical flow ansatz only accounts for image structures of first order, i. e. it can only function in the case of relatively small shifts. Alternative approaches of higher order have been developed, so that a reliable registration of larger motions is also possible.

The contact person in the field of "3D Matching" is Dipl.-Phys. Andreas Jablonski (phone: 06 31/3 03-18 65).



The figure explains the problem. Target volumes (blue) and risk areas (red) are represented in the scheme which change their position, shape, and orientation between the fractionations. If the original position of the radiation head is maintained, the therapy is quasi useless.

Cryptography

In order to guarantee the protection of information from unauthorized access in a time relying on electronic data transfer, a continuous development and refinement of cryptograhic methods is necessary. The application of public key cryptosystems, also called asymmetric methods, plays an essential part in achieving the objective of secure communication.

The most well-known asymmetric cryptosystem today is RSA (after Ronald Rivest, Adi Shamir, and Leonard Adleman). Its security is based on the fact that the factorization of a "large" integer number which is the product of two primes is generally considered to be difficult. However, in the last few years considerable progress has been achieved with respect to the factorization of large numbers.

Due to this development, it is important that alternatives are available. Elliptic curves have proved to be a good basis for cryptosystems which can seriously compete with RSA. Their security is based on the problem of computing discrete logarithms in the group of rational points on an elliptic curve. In general, this is already difficult for relatively small parameters, therefore these systems guarantee high security already for small keys, which is why they are especially used for Smart Cards and other environments where only a limited memory is available.

Hyperelliptic curves are generalizations of elliptic curves. Although research has not progressed so far yet as in the case of elliptic curves, they can nevertheless be used for the construction of secure and efficient cryptosystems comparable to RSA.

Within the project, we examine how the parameters must be selected in order to reach this objective. Actual research is focused on the development of methods for the determination of hyperelliptic curves suitable for cryptography, and on the acceleration of the arithmetic, which means a run time improvement of the respective cryptosystem. Our partner is the company BGS Systemplanung AG in Mainz.

The colleagues in the field of competence are Dipl.-Math. Norbert Göb (phone: 06 31/3 03-18 61) and Dipl.-Math. Georg Kux.

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Sitting: M.Sc. Siana Halim, Dr. Katja Schladitz
Not in photograph: Dipl.-Phys. Martin Braun, Dipl.-Math. Norbert Göb


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LAMM
SCHWEINEFLEISCH
GEFLÜGEL

Adaptive Systems

The main competences of the department ADAPTIVE SYSTEMS are "Computer-aided Analysis of Analog Circuits", "Diagnosis and Prognosis Systems", "Model-based Monitoring and Control of Mechatronic Systems", as well as "Material Models". In the middle of the year summarized by this report, Dr. Patrick Lang succeeded Prof. Dieter Prätzel-Wolters as Head of the Department. Simultaneously, according to our planning the previous research group "Financial Mathematics" became an individual department, headed by Prof. Ralf Korn.

The entire department ADAPTIVE SYSTEMS looks back on a very successful year, where primarily the marketing of the developed software products has made significant progress. Further positive developments are expected.

In this context, a special success was the integration of "Analog Insydes" into the design flow of Infineon Technologies AG, a producer of semiconductors. Besides, an increasing interest could be observed in the monitoring tool for torsional oscillations which has been developed in the department.

A special honor was the presentation of the Innovation Award 2001 of the state Rhineland-Palatinate for the software product "Analog Insydes". The official release of the new version 2 of Analog Insydes will take place in the spring of 2002. Compared to the first version, the new release offers considerably extended functionality. In particular, the analysis of nonlinear circuits is also supported now.

Objectives for the year 2002 are the expansion of the research area life sciences in particular, apart from a consequent refinement of the department's products and a further development of competences.

Analog Insydes:
Computer-aided Analysis of Analog Circuits

Companies producing analog integrated circuits have a high demand for computer-aided methods which improve design security and help shortening the development periods. Up to now, apart from numerical simulation methods, only very few tools have been available for the analog circuit design in order to get a more detailed insight into the behavior of a circuit. To close this gap, the software tool "Analog Insydes" is developed at the Fraunhofer ITWM, which integrates symbolic and numerical methods for the modeling, analysis, and sizing of linear and nonlinear analog circuits.

Analog Insydes version 2

In the period accounted for by this report, efforts were concentrated on finishing the new version 2 of Analog Insydes. One of the results is a manual of approximately 500 pages which comprises a reference part and a detailed tutorial providing the user with an easy introduction into Analog Insydes. Besides, the entire documentation is also integrated electronically in the online help system of Mathematica.

A fully functioning free demoversion can be downloaded for a limited period of 30 days from the following address: www.analog-insydes.de

On the basis of a hierarchic netlist format and a flexible modeling language, Analog Insydes can be applied for the design of analog circuits and control systems. An extensive model library is available (R, L, C, Diode, BJT, JFET, MOS). Analog Insydes can be used with numerical as well as symbolic methods for DC-, AC-, and transient analysis, for the analysis of temperature, noise, and poles/zeroes, and for parametric analyses. Especially important are the automatic equation setup (symbolic and numerical) and the symbolic approximation methods for linear and nonlinear circuits. The results can be visualized by a large number of

graphic functions, e. g., Bode and pole/zero diagrams or transient and root locus plots. Analog Insydes is completed by interfaces to the circuit simulators PSpice, Eldo, Saber, and Titan, so that, e. g., the input of schematics, netlists, and simulation data is possible, or Saber MAST behavioral models can be generated.

Current research

Within the European joint research project Anastasia+, new methods for the automatic generation of nonlinear behavioral models have been developed. Besides, we have examined whether such models can be translated into the behavioral description language VHDL-AMS, and applied respectively.

As a new research area, examinations with respect to the interval arithmetic have been carried out. In practice, electronic components are subject to tolerances due to production. The influence of these tolerances on the circuit behavior is supposed to be predicted reliably through the application of interval arithmetic. Already existing numerical algorithms must be fitted to the special requirements of the interval arithmetic.

Applications

After the integration of Analog Insydes into the design flow of Infineon Technologies in the last year, the tool could be established firmly on the market for circuit design. Motivated by experience in industrial applications, additional interfaces have been included into Analog Insydes, and the integration into the Infineon environment has been improved.

User seminars

For professional users, the ITWM organizes a seminar of several days where theoretical and practical knowledge with respect to the application of Analog Insydes for circuit design is offered.

The colleagues in this field of competence are Dipl.-Ing. Thomas Halfmann (phone: 06 31/2 05-44 75), Dipl.-Math. Tim Wichmann, and Dipl.-Math. Alexander Dreyer.

The research group "Computer-aided Analysis of Analog Circuits" is one of the winners of the Innovation Award 2001 of the *Land* Rhineland-Palatinate. In the field of research, the first prize endowed with 5,000 German marks was divided between the Fraunhofer ITWM and the Fraunhofer Institute for Experimental Software Engineering (IESE).

Diagnosis and Prognosis Systems

The research group deals with the development of methods for the prognosis of the behavior and the diagnosis of complex systems, on the basis of data and knowledge. In particular, the research is focused on those processes and systems which do not or only partially allow an explicit model description due to insufficient information or high complexity.

By a systematic data mining of measurement data, knowledge about the system can at least be acquired indirectly. For this purpose, techniques from the fields of cluster analysis, classification methods, neural networks, as well as linear and nonlinear time series analysis are applied. In order to model the expert knowledge which provides a prognosis of the system on the basis of the analysis results, methods from Fuzzy Logic and Adaptive Control structures are used. The quality of the resulting prognosis and diagnosis tools is checked by statistical methods, such as Bootstrapping or Cross Validation.

One of the main subjects of the research group is computer-aided diagnostics in medicine. Expert systems combine the results of the data mining with the knowledge and experience of the physician. They can analyze medical data and facilitate the evaluation by generating hypotheses and supporting their validation. The result are computer programs for the support of diagnosis and therapy. Current projects in this area deal with the risk stratification of long-term electrocardiograms, the diagnosis support in Regulation Thermography, and the development of nutrition expert systems.

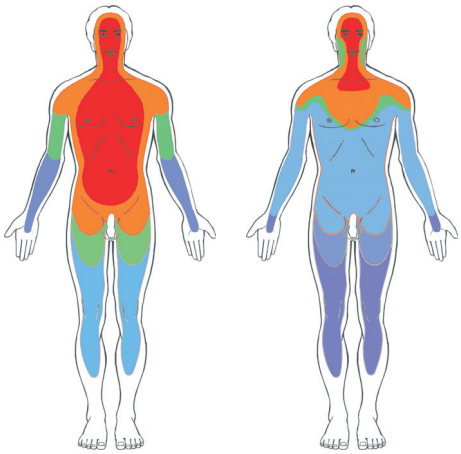
The projects of the research group "Diagnosis and Prognosis Systems" are coordinated in close cooperation by Dr. Hagen Knaf (phone: 06 31/2 05-44 74), Dr. Alexander Sarishvili, Dipl.-Inform. Harriet Bach, and Dipl.-Math. Stefan Soltuz.

Regulation thermography

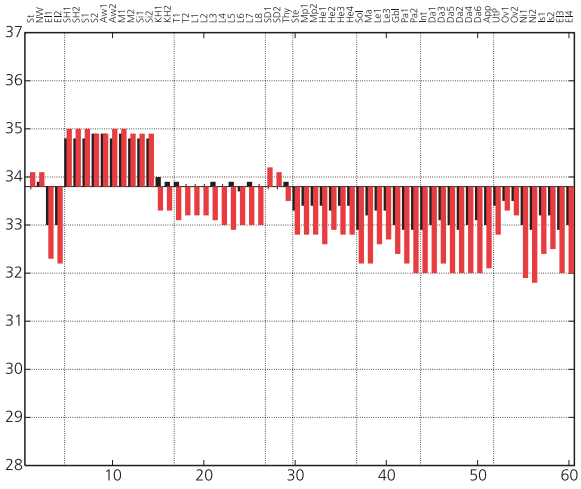
Regulation Thermography is a complex diagnosis method of complementary medicine which is based on the evaluation of thermal patterns. By two measurements of the body temperature at 110 defined points – before and after a cold stimulus usually induced through taking off the clothes –, a so-called thermogram is generated. Especially trained physicians can conclude pathologic processes in the body from the patterns occurring in the thermogram, e. g., the development or growth of a tumor. Here, evaluation rules are used which can be modeled very well using Fuzzy Logic. In the case of the female breast cancer, approximately 100 of such rules have been implemented into an expert system which examines thermograms with respect to indications of tumor cells. The statistic validation of the expert rules and of the quality of their implementation in Fuzzy Logic is performed by comparison with thermograms evaluated by experts. Here, methods of nonlinear discriminant analysis are available which can also provide hypotheses for new interpretation rules. The flexibility of the evaluation system due to the possible expansion of the basic rules is further increased by the addition of a neural network.

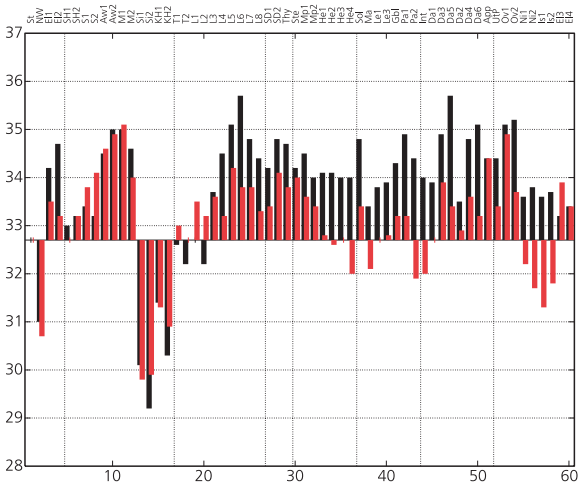
The neural network receives fuzzy logical evaluations of parts of the thermogram as input data and also provides an evaluation of the thermogram with respect to a possible activity of tumor cells. Hence, a part of the expert rules is used in order to pre-process the thermogram data, thus decreasing dimensions. Through a post-training, the network can always be adapted to new data material.

The weighted average of this double thermogram evaluation – by pure fuzzy logic and by fuzzy logic in combination with a neural network – is then further processed.



Effects of a cold stimulus



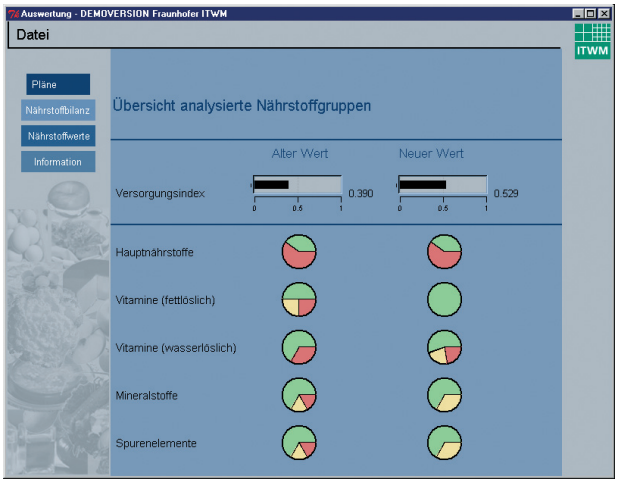


Comparison of an ideal thermogram (left) with the thermogram of a breast cancer patient (right): the temperature measured before the cold stimulus is black, the temperature measured afterwards is red.

Nutrition optimization

The "fuzzy" methods of fuzzy logic are also applied within a project for the development of a nutrition consultation system. The user describes the diet of several days by a diet plan, which comprises type and amount of the food which has been consumed and is evaluated with respect to the supply of the most important nutrients, vitamins, and trace elements. An optimization step then provides the user with proposals for an improvement of the nutrition behavior. This step can and should be repeated several times, because it is an important condition of the optimization that the changes of the diet plan per step do not become too extreme.

The optimization steps are controlled by a target function which comprises the expert knowledge of nutrition consultants.



User interface of the PC prototype version of the nutrition expert system: based on the input data with respect to the individual actual ingestion, an optimization is carried out also accounting for the usual individual diets.

Simulation of software development processes

Apart from the field of medicine, techniques of data mining are also applied for the prediction of complex material properties, such as fatigue, abrasion behavior, or crash performance. Often, the physical models for the description of these phenomena are only insufficiently known, so that there are hardly any alternatives to a data-based method. Another project of the research group deals with the simulation-based evaluation and improvement of software development processes.

In contrast to the simulation of production processes, the human factor plays a decisive part during software development, influencing the duration of the development period and also the quality of the software.

In order to guarantee quality during software development, early software inspections should be carried out. The developed software tool is supposed to support the project manager with respect to his/her decision about the time when an inspection leads to quality improvement under the given specific conditions.

The research group identifies the different influence factors of the software development process by appropriate data mining techniques, and generates adequate rules in order to enable the simulation and a following optimization (see p. 81).

Model Based Steering and Control of Mechatronical Systems

The research group is specialized on mathematical methods for system identification and model updating, as well as for the design of observers and controllers. At the moment, the methods are primarily applied in the field of mechatronic systems, especially electric machines such as turbine generator shaft lines.

System identification and model adaptation

At the beginning of the work with a technical system, usually a mathematical model is developed which represents the interesting aspect of the system as exactly as possible. The applied mathematical methods are selected individually according to the information available about the system. If only the input-output behavior is known – a so-called black box –, the first attempt is an identification of the system by linear methods (e. g., ARX or ARMA models). If these approaches are not successful, more complex nonlinear techniques like neural networks are applied. However, if the structure and the physics of a system are partially or completely known, the modeling must account for this information. This is called a grey box or white box modeling.

In order to model the torsional oscillations of turbine generator shaft lines, e. g., the finite element method is used, which results in the so-called equations of motion, a high-dimensional system of coupled differential equations of second order. This is also an approximation method, since at least several parameters are unknown or only known as an approximation. Often, additional measurements of modal system parameters are available apart from the geometrical and physical parameters. If these measurement results are accounted for, the quality of the model can be further improved by appropriate model adaptation techniques. However, on the one hand mostly more analytical data are available than corresponding measurement data, and on the other hand, due to technical restrictions the individual mode shapes of the systems cannot be measured at each node where an analytical mode shape can be computed . Thus the measured mode

shapes must be expanded appropriately. Therefore, apart from measurement errors, expansion errors must absolutely also be accounted for during the updating process.

Design of observers and controllers

On the basis of the identified system models, mainly methods of H_∞-control theory are applied for observer and controller design, apart from the classical methods. The advantage of these methods is that the resulting observer or controller is robust with respect to model uncertainties and other system disturbances. If the system to be controlled is subject to strong time-dependent variations, appropriate adaptive control methods are applied.

In the field of "Model-based Monitoring and Control of Mechatronic Systems" are working Dipl.-Math. Andreas Wirsen (phone: 06 31/2 05-31 26), Dipl.-Math. Frank Kneip, and Dr. Patrick Lang.

The methods of model updating and observer design are applied, e. g., within the software product TorAn, a tool for the online monitoring of torsional oscillations and the fatigue analysis of rotating machines. Based on the exciting moments and a measurement of the torsional oscillations at a shaft element, TorAn estimates online the torsional oscillations at the interesting shaft sections by a robust, model-based observer. TorAn recognizes disturbances and analyzes the fatigue for the selected shaft elements in the case of such a disturbance. The results of the analysis are available to the user via the graphic interface of TorAn. A visualization of the time-series of a disturbance is also possible in time and frequency domain.

The torsional oscillations are measured by a remote torque sensor marketed by the ITWM. The signals provided by the sensor are made available to TorAn for a further analysis via a measuring card.

At the moment, TorAn is tested in the power plant Bergkamen (air photograph above). The remote sensor (below) measures the torsional oscillations of a 747 MW turbo set directly at the shaft (with friendly support of the electrotechnical department of the Steag and RWE Power Plant Bergkamen).

Material Models

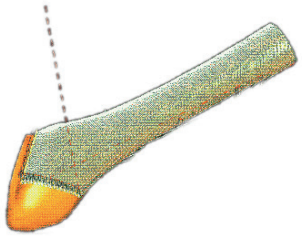
In this field of competence, mathematical models and asymptotic homogenization algorithms are developed for the computation of the averaged (effective) properties and microstresses of composites or porous materials on the basis of known properties of their components and their microgeometry. Homogenization is required in very different mechanical and chemical processes in composites and porous media: as soon as there are two or more different parameter scales in their micro- and macrostructure, the direct numerical computation becomes very complicated or even impossible. The homogenization method first introduces a small parameter corresponding to the scaling factor between the characteristic micro- and macro-lenghts in the problem. The solution of the problem is then developed asymptotically with respect to this parameter, resulting in an equivalent homogenized problem at the limit, which is easier to compute.

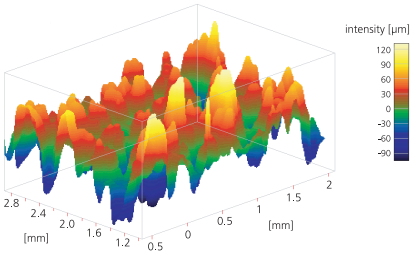
The homogenization method can be applied for the computation of a large number of averaged properties of composites and porous media, such as stiffness, viscoelastic properties, free shrinkage, free swelling, free thermal expansion, strength, fatigue strength, and wear. Basically, all these properties can be computed from the properties of the components on a periodicity cell via the microgeometry of the composites. Moreover, they do not depend on external conditions, such as loading and temperature.

Examples for industrially interesting processes which can be computed with the homogenization method are: corrosion, degradation, desiccation, fatigue, and wear of reinforced resins, concrete, and wood. Concrete application projects of the department were, e. g., the computation of the effective viscoelastic and shrinkage properties of particle-reinforced dental fillers and floorings.

The expert in the field of "Material Models" is Dr. Julia Orlik (phone: 06 31/2 05-27 42).

Application of cementless hip prostheses





Titanium prostheses are coated with a plasma spray, which gives a clear microstructure to the surface, improving the contact to the bone, and therefore the durability of the prosthesis.

This research project, which is funded by the European Union, deals with the improvement of the durability of cementless hip prosthesis. In this context, the contact conditions between the bone and the microscopically rough surfaces of the prosthesis are considered. With a two-scale approach, the microstresses in the boundary layer between bone and prosthesis can be approximated, accounting to the microgeometry in the boundary layer and the stiffness of the prosthesis coating and the bone.

The mechanical microcontact is modeled as the non-penetration condition, which is approximated in the variational formulation through penalization. The penalty coefficient is called contact stiffness in the terminology of the FE-softwares. A further condition is the Coulomb friction for the contact area. Mathematically speaking, such contact conditions are called conditions of third type.

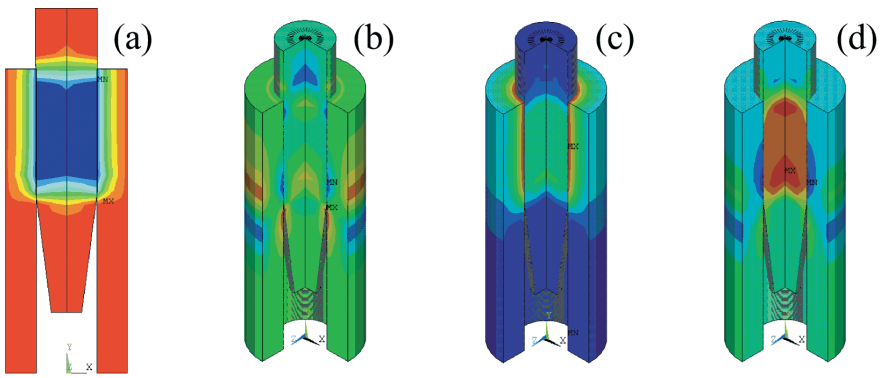
If we consider the boundary in the weak formulation of the microproblem, the result is a homogenized problem where the boundary layer is substituted by a homogenized contact condition. The homogenized contact stiffness and the homogenized friction coefficient are computed by averaging the respective values on the microscale over the contact area included in the periodicity cell. The results which have been achieved in the project up to now only hold for known plane microcontact areas which guarantee the linearity of the problem.

The derived macrocontact condition is then integrated into a FEM computation for the homogenized contact problem, where the macro-shape of the prosthesis, the strength and stiffness of the bone and the titanium are the only input parameters.

The objective for the following year is the development of solution algorithms for unknown microcontact areas.

Another current research project deals with the examination of the effective strength, fatigue, wear, and shrinkage of particle-reinforced resins.

The simulation shows the stresses to which bone and prosthesis are subject:
(a) radial stress, (b) axial stress, (c) equivalent von-Mises stress, (d) equivalent von-Mises strain.



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Not in the photograph: Dipl.-Math. Frank Kneip, Dipl.-Ing. Jutta Praetorius, Dipl.-Math. Stefan Zeiser

Optimization

In the OPTIMIZATION department focus is given to research and application of models and methods of mathematical optimization for industry, the service sector, and the public sector. The development of the corresponding software according to the customer's needs plays an important part.

The department comprises the following fields of competence:

- in-house logistics
- global logistics
- traffic planning
- decision support in life sciences, and
- knowledge management and e-commerce

The methods applied range from graph theory and special combinatorial optimization methods to large-scale optimization. Some projects also involve the use of commercial solvers. Algorithms of online optimization and multicriteria optimization, as well as simulation methods are also developed and applied.

The year 2001 was an extraordinarily successful year for the department, not only from an economic point of view. There was also a considerable increase of the personnel by more than 15 per cent. Almost all the customers remained loyal, and several new customers could be won. A first project together with our partners from FIMIM in Florence is another example for the positive development (see also "internationalization", p. 10) of the department. Besides, the cooperation with other Fraunhofer Institutes could be reinforced by projects in the framework of a program of the Federal Ministry of Education and Research (BMBF) "Leben und Arbeiten in einer vernetzten Welt".

In the fields of logistics, there was an above-average growth. This is especially due to the area of e-commerce, which has become an individual field of competence. In "Decision Support in Life Sciences", two large projects with respect to the planning of cancer radiation therapy have been started.

The projects are supported by the cooperation with the research group "Mathematical Optimization" of the University of Kaiserslautern.

In-house Logistics

Research area "In-house Logistics" offers extensive solutions for complex problems of the planning, control, and optimization of technical and organizational processes. The competences of the stuff working in this area and the use of efficient software tools enable them to successfully solve both traditional logistic problems and problems whose complexity and dimensionality represent a scientific and technical challenge thus requiring the development of specialized efficient solution methods.

The applied decision techniques are based on the integration of simulation and optimization. Among others, methods and approaches of discrete event simulation, linear and integer optimization, and multi-criteria decision theory are used.

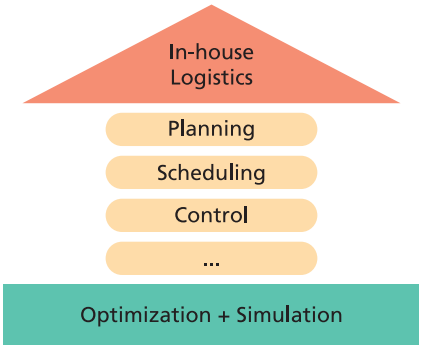
The mentioned techniques have been successfully applied in numerous industrial projects, e. g., for the development of assignment strategies for assembly lines in automobile industry and for the simulation of a complex order-picking system containing high-performance inventory management systems (Rotastores). Simulation has also been used to support scheduling decisions. A scheduling system for a foundry has been developed which allows to take into account many complicated specific organizational features which cannot be represented analytically. Among the main industrial partners are PHB Stahlguss GmbH (St. Ingbert-Rohrbach), psb GmbH Materialfluss + Logistik (Pirmasens), Pierau Planung (Hamburg).

Optimization and simulation methods have also been applied in the service sector, especially in the field of health service. One project, for example, intends at efficient planning of patient transports in hospitals.

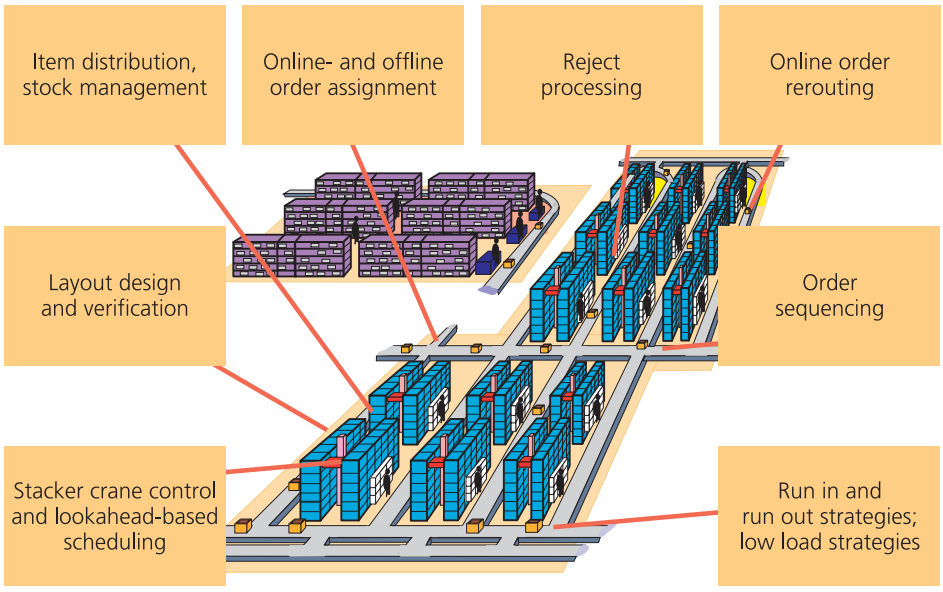
Apart from industrial projects, the research group "In-house Logistics" also carries out publicly funded research. An example is the project SILVER ("Simulation-based Systems for the Integration of Decision Processes in Logistics and Process Engineering"), funded by the Federal Ministry of Education and Research (BMBF), where concepts, algorithms, and implementation methods are developed which are intended to couple the discrete simulation typical for logistics, and the continuous simulation relevant for process engineering. In this project, optimization is an important part of decision making processes. Close cooperation with the partner institutes Fraunhofer IML, Fraunhofer UMSICHT, and Fraunhofer FIT is especially successful here. At the Fraunhofer ITWM, apart from the department OPTIMIZATION, the department TRANSPORT PROCESSES also participate in the project. Future application of the results achieved in the project is supposed to facilitate a faster marketing of innovative products.

"Simulation-based Evaluation and Improvement of Software Development Processes" is the subject of a further project – in cooperation with the department ADAPTIVE SYSTEMS –, which is funded by the BMBF and carried out together with the Fraunhofer IESE and the Fraunhofer FIT. The objective is the development of a simulation platform in order to determine and demonstrate the effects of software development processes in industrial environments at reasonable costs. Such a tool is primarily intended to improve the planning and optimization of software development.

The team of "In-house Logistics" consists of Dr.-Ing. habil. Alexander Lavrov (phone: 06 31/2 05-44 45), Dipl.-Math. Julia Cheredova, Dr. Michael Eley, Dr. Thomas Hanne, and Dipl.-Math. Torsten Schneider.



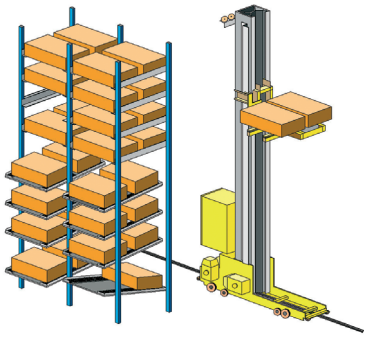
The solution of logistic problems is based on a combination of simulation and optimization.



In the case of the development or improvement of technical infrastructure, or the control of modern automized warehouse management and order-picking systems, problem solutions require a complex mathematical background.

Simulation and optimization of a mail-order company

The control of complex dynamic order-picking systems for high-bay warehouses requires refined mathematical optimization strategies.
© psb GmbH



High-bay warehouse with order-picking system
© psb GmbH

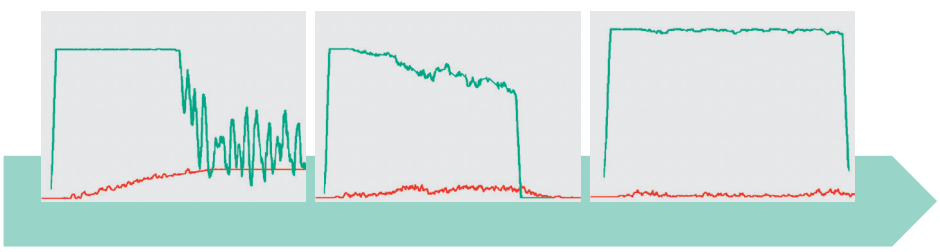
The project described here illustrates the versatility of problems in the field of "In-house Logistics". The objectives were, among others, the following:

- design of a detailed simulation model for palette and container order-picking,
- development of an efficient item distribution strategy,
- finding the optimal strategies for order handling,
- development of control strategies for dynamic routing,
- determination of optimal system parameters such as buffer capacities, line speeds, performance of the stacker cranes,
- prevention of traffic lams and deadlocks,
- development of starting and running-out strategies and measures in the case of low-cycle situations.

The system under development was characterized, in particular, by a product range consisting of several thousand articles, strongly varying demand for different articles, a throughput of several thousand orders per hour, as well as short-term changes of the order pool.

Simulation-based and analytical investigation helped detect weaknesses in the original layout of the order-picking system. With the new layout, developed in cooperation with project partners, the requirements on transport capacities were met, while the number of the required stacker cranes was even reduced by up to 45 per cent. In addition, a more flexible order assignment and routing became possible.

The developed control strategies are based on the coupling of strictly mathematical methods and heuristic decision methods. They can be applied both online and offline and are able to produce efficient solutions for complex multi-criteria problems. The strategies of item distribution and online order routing enable a good load balancing of order-picking stations and a higher system utilization, at the same time prevention overloads of the handling system. Specially developed methods of multi-stage lookahead-based planning of item relocations result in essential improvements of stacker crane performance. The algorithms of dynamic rerouting facilitate a smooth operation of the system and an operative processing of failures and local bottlenecks.



Simulations for an order-picking system on the basis of different optimization strategies: the intention is to provide an output as uniform as possible (upper curves) and to minimize the number of "stray" items within a certain period.

Global Logistics

This research area focuses on the development of mathematical optimization models and methods for the analysis, planning, and control of global value added processes. Applications are, e. g., the planning of sales districts or the strategic and tactical planning of supply chain networks.

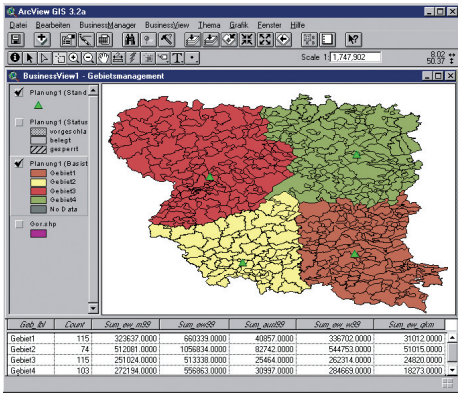
In the process of planning sales districts, small geographic (sales) coverage units are grouped into larger connected districts in such a way that the latter are acceptable with respect to different managerially relevant criteria, such as purchasing power, area, etc. (see fig. on p. 84 above). Simultaneously, within each new district the location of a sales center is determined in such a way that the sum of the distances from this location to the sales units in the district is minimized. This problem often occurs in companies which are looking for market areas and locations for their sales representatives. The planning of sales districts can be modeled as a discrete facility location problem, and solved using exact optimization methods as well as heuristic procedures. The latter methods show a high flexibility with respect to the integration of application-specific planning criteria.

The field of location theory is also essential in the project "KogiPlan: Cooperation, Geographical Information Systems, and Decision Support in Location Planning", funded by the Federal Ministry of Education and Research (BMBF). The objective of the project is the development of an integration platform for data mining, optimization and visualization tools which supports decision processes in all the phases of location planning.

A further research area is the application of optimization methods with respect to emergency logistics, e. g., the location planning of emergency units and the evacuation planning of individual buildings or entire regions. In cooperation with the department FLOW IN COMPLEX STRUCTURES and four other Fraunhofer Institutes, a survey has been carried out in the summer of this year, meeting strong resonance among experts. The objective of the study was the determination of the demand for IT support in the case of disaster and emergency management.

In the group of "Global Logistics" are currently working Dr. Teresa Melo (phone: 06 31/2 05-44 26), Dipl.-Math. Patricia Domínguez-Marín, Dr. Michael Schröder, and Dipl.-Math. Jörg Kalcsics.

Optimal planning of supply chain networks



Zip code areas are grouped into four approximately equally balanced sales districts (graphical display with the geo-marketing software *BusinessManager*®, an *ArcView*® *GIS* extension of our project partner geomer GmbH).

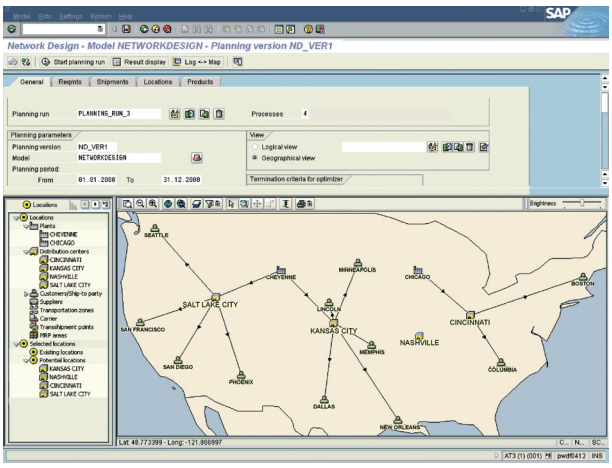
Supply chain management deals with the planning and optimization of activities (e.g. procurement, production, distribution) which take part in the whole operation of a supply chain and involve different cooperating business partners (suppliers, logistic providers, traders). The objective is to meet the (customers') demands in such a way that the overall costs are minimized subject to various side-constraints.

Decisions taken on the strategic level have a long-range scope and a decisive influence on the entire operation and efficiency of a supply chain network. For our partner, SAP AG, we have developed the software tool *Supply Chain Design*, which includes models and algorithms for the decision support with respect to the strategic planning of supply chain networks in the following areas:

- procurement: which amount of material should be purchased from which supplier?
- production: where should specific products be produced and in which amounts?
- distribution: which transport lanes should be used?
- facility location: how many new facilities (e. g., production plants) should be opened where? Which ones of the existing facilities (e. g., warehouses) should be closed?
- customer allocation: which customer should be served by which facility?

The optimization of a supply chain network takes different cost structures into account ranging from fixed charges for the opening of new and closing of existing facilities to procurement, production, and transport costs. Furthermore, production and handling resources of limited capacity are considered which can be extended – e. g., by overtime work –, at the expense of additional costs. The objective is to determine the optimal number of operating facilities and their locations, as well as the amount of products to procure, the amount of products to manufacture and the flow of products throughout the network in order to minimize the overall costs. The resulting problem is formulated as a mixed integer linear programming problem and solved with the optimization software CPLEX®. The optimization results can be visualized graphically or in tabular form for the decision maker.

Supply Chain Design is a module within the software *APO* (*Advanced Planner and Optimizer*), developed by SAP, which supports the organization and operation of supply chain networks.



Optimized supply chain: from the four potential locations for new warehouses, three were selected. The figure also shows the optimal assignment of customers to warehouses and of warehouses to production plants with respect to costs. (graphical display with the *APO Supply Chain Design* software, © SAP).

Traffic Planning

The objectives of the projects in the field of competence "Traffic Planning" are the creation of new potentials for public transport, the inter-modal combination of different transport means, and the cost efficient strengthening of railway traffic.

Actually occurring planning problems of public and private transport companies are solved by methods of mathematical optimization. Typical applications on the one hand include aspects of infrastructure planning, e. g., the problem of finding appropriate locations for new railway and bus stations in local public transport, which is the subject of a project together with the Deutsche Bahn AG. Another aspect is the construction of inter-modal distribution networks for mail service providers. Besides, problems of operation sequencing are also examined, such as the improvement of line changing processes between different means of public transport. A further research area deals with the tariff planning for large public transport communities, such as the introduction of tariff zones in Saxony-Anhalt.

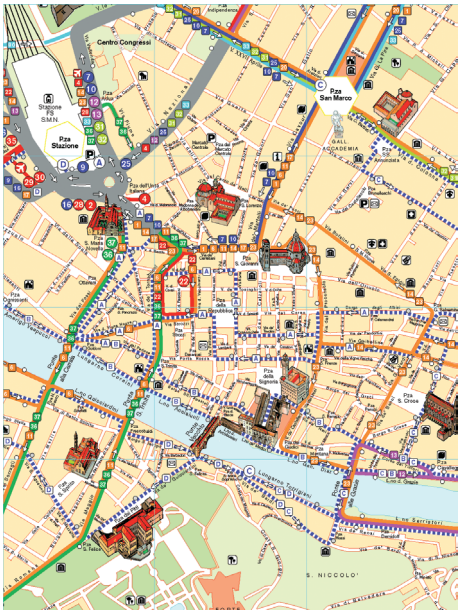
In the framework of the German-Italian cooperation FIMIM (compare also the remarks about "internationalization" on p. 10), the task is the conception of a new city railroad system in Florence, including problems of infrastructure planning and operation sequencing (see p. 86, second figure from above).

The mathematical tools applied within the projects include methods of graph theory, location planning, network design, and heuristic and exact combinatorial optimization.

The colleagues in the field of competence "Traffic Planning" are Dipl.-Math. Tim Sonneborn (phone: 06 31/2 05-44 73) and Dr. Michael Schröder.

Delay management in multi-modal public transport systems

The security and optimization of connections between different public means of transport, e. g., busses and trains, is difficult especially within larger dense public transport networks.



The actual public transport network in the city of Florence

Suppose that a train arrives late at the station. Now, the problem is whether the busses waiting at the station should wait for passengers from the train which is delayed, or whether they should depart on time. Such a question can easily be answered in the case of one single bus station. However, within a large public transport network the problem quickly becomes very complicated.

Within the actual research project, models for delay management are developed which can be applied in practice by large public transport communities. We particularly take into account that the models are based on existing data, and that they do not only consider the changing of lines of the same company, but also the changing of lines offered by different companies, e. g., in the case of railway passengers continuing their journey by bus. The models can be applied in the case of actual delays, as well as in the case of changes and restructuring of the schedules. The following individual questions are dealt with:

- Which effects do delays have on the system?
- Which connections should be guaranteed in the case of a delay?
- Where are the weaknesses of existing schedules with respect to delay management, and how can these be eliminated?
- Which effects do changes of the schedule have on the system?
- How can the schedule be adapted to previously known obstacles (e. g., road constructions)?

These problems are the basis of the current project, which is funded by Foundation Rhineland-Palatinate for Innovation and dealt with in cooperation with the Public Transport Community Rhine-Neckar (VRN), the Public Transport Community Saar (VGS), and the German Railway (DB), region Frankfurt. Mathematical optimization models are developed which use methods of network planning able to compute the effects of delays or schedule changes efficiently. Finally, the occurring delays are visualized graphically.

All the methods are tested in two regions: in the Palatinate on the line of the Lautertal Railway between Kaiserslautern and Lauterecken, which can even influence the area of Mannheim-Ludwigshafen, and in the Saarland, in the region of Saarbrücken-Homburg-Wemmetsweiler.

The line of the Lautertal Railway is particularly appropriate for testing because the project "Automat im Zug" of the German Railway is installed here, where, e. g., a system has been implemented which informs the bus drivers at the stations about the actual arrival of the trains. In combination with this project, rules are developed which support the decision how long a bus should wait at most for a delayed train.

The results of the project are supposed to support the traffic planning of the respective public transport communities with respect to the structure of schedules, as well as to the reaction to unexpected events.

Decision Support in Life Sciences

In public, high-tech in life sciences is mainly identified with methods of genetic engineering, image processing in medicine, or micro-surgery. The development of these methods is based on enormous progress with respect to the acquisition of image data of complex structures in nature. The resulting huge data potential is far too much for human reception capacities, thus requiring the use of analytical tools.

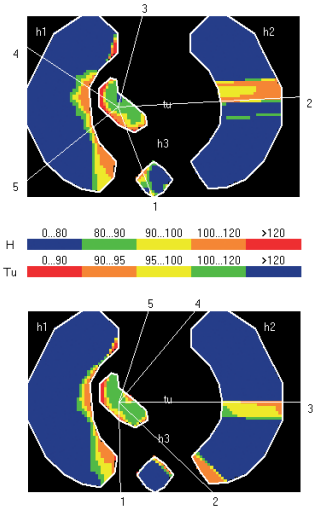
A typical example is the evaluation of medical images for the diagnosis or the planning and accompanying of therapies. In order to manage the input of large amounts of data and to decide about therapy concepts, physicians and planners need structural help provided by abstract models and their consequent description. Up to now, in the field of medical technology, primarily methods of mathematical physics are applied, whereas mathematical methods from the field of industrial mathematics are almost unknown.

This is where the research group of the Fraunhofer ITWM begins to work by transferring methods of economic operations research to problems of life sciences. The research is focused on multi-criteria decision methods, methods of online adaptation of process parameters, and use of discrete structures in modeling and algorithmic realization.

At the moment, two projects from the field of clinical radiation therapy planning are in the center of this scientific competence. Moreover, preparations of additional projects currently deal with discrete optimization algorithms in order to facilitate the detection of replication origins in genome sequences.

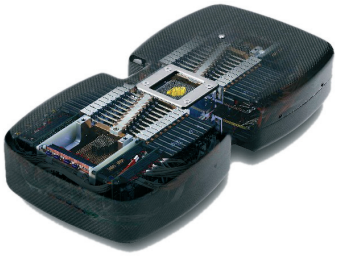
In the field of "Decision Support in Life Sciences" are currently working Dr. habil. Karl-Heinz Küfer (phone: 06 31/ 3 03-18 51), Dipl.-Math. Michael Monz, Dipl.-Math. Alexander Scherrer, and Dipl.-Math. Hans Trinkaus.

Multi-criteria planning concepts for radiation therapy



The optimization of irradiation geometries in the case of intensity-modulated radiation therapy planning makes special sense if the radiation heads only reach a part of the relevant body surface. The image above shows the optimal equidistant selection of the irradiation geometry, whereas the image below represents an optimal irradiation geometry without any limits with respect to the equidistant position. The potential for improved optimization methods can be recognized.

A multi-leaf collimator is a computer-controlled shield which fits the contour of the radiation to the shape of the tumor. On the one hand, the radiation can be directed more exactly towards the tumor tissue, and on the other hand, the surrounding tissue is less endangered.



The structure of the project RADIOPLAN, which is funded by the Federal Ministry of Education and Research (BMBF) and dealt with in cooperation with the Fraunhofer SCAI, is mainly concentrated on basic research. However, it ideally supports the practical project "A Dynamic Real Time Tool for the Improvement of Conformation Radiotherapy Planning", in cooperation with the German Center for Cancer Research and the University Hospital of Heidelberg, about which we have reported in detail on page 92 of last year's annual report.

It is the task of clinical radiation therapy planning to find a compromise between a radiation dose which is sufficiently high for the tumor tissue and simultaneously does not endanger the surrounding tissue as far as possible. The main problem of the computer-aided search for optimized therapies with respect to the individual patient is the determination of an adequate evaluation mechanism for therapy plans. In current practice, the therapy plans are evaluated by one single "mark", which represents a weighted mean of individual evaluations of dose distributions in all the relevant entities, target volumes, and risk organs. However, the clinical quality of a therapy plan is also judged according to different organ-specific criteria which are not accounted for in this evaluation mechanism. Since dynamic corrections of the weights are nearly impossible, this results in a time-consuming trial-and-error search process.

On the basis of methods from multi-criteria decision theory, ITWM researchers compute physical setups of therapy plans and file them in a database. The overall evaluation function is substituted by individual evaluations which are optimized independently. Based on the Pareto solution method of multi-criteria problems, representative systems for efficient solutions are then computed. These can be searched interactively by the physician with a simple navigation mechanism, for which the Fraunhofer ITWM has submitted a request for granting a patent.

From a mathematical point of view, the problem can be formulated as a multi-criteria convex large-scale optimization problem. Essential elements of the project are the efficient numerical treatment and adaptation of the model parameters, as well as the consequent utilization of computer architectures.

A further problem in the field of radiation therapy planning is the efficient physical realization of therapy plans by multi-leaf collimators, which can be modeled with the aid of special network flow problems for step-and-shoot strategies. The simplification of the physical realization of radiation therapy directly results in shorter therapy times and therefore in a better clinical acceptance.

The project RADIOPLAN represents a cooperation of several departments of the Fraunhofer ITWM. The department Transport Processes works on the basic research with respect to the modeling of the dose absorption by flow dynamical equations, while the department Models and Algorithms in Image Processing carries out a feasibility study with respect to the problem of the adaptation of dynamic patient geometries.

Knowledge Management and E-Commerce

Features characterizing differences between companies are increasingly difficult to recognize in the classical operative areas. Therefore, primarily in the case of production enterprises, competitive advantages must be achieved in strategic areas, e. g., with respect to product and process innovation, and increasingly also with respect to the evolution of customers, products, and personnel. An appropriate foundation is an effective and efficient knowledge management which generates, structures, and files company-specific know-how, and integrates redundance-free methods for the optimization, simulation, and visualization of company-relevant resources and business processes.

This directly leads to a main subject in the field of competence "Knowledge Management and E-commerce": the modular "KnowledgeBox for Decision Support", which has been developed in order to support the entire complex of innovation, resources, and project management, and simultaneously realizes strategic controlling and operative management.

In industrial practice, several modules of the "KnowledgeBox" already prove their efficiency. They are completed in the framework of a project where companies from different branches are participating. The main objective is the detection of their common features and the initiation of an interdisciplinary transfer. At the same time, the modularity of the "KnowledgeBox" guarantees that each participant of the project receives an individually adapted module where uniformity would be inappropriate and contra-productive.

The modules of the "KnowledgeBox" comprise, e. g., flexible checklists which simultaneously serve an efficient project management and the automatic presentation and acquisition of knowledge, and a pre-structured workflow connecting all the participants of the project and initiating subprocesses.

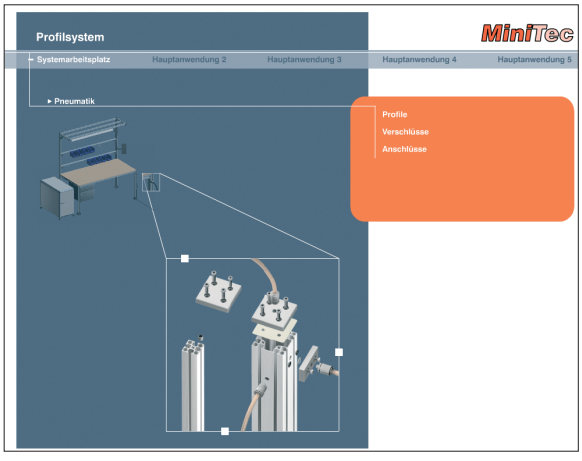
In this research area are working Dipl.-Math. Hans Trinkaus (phone: 06 31/ 3 03-18 55), PD Dr. Karl-Heinz Küfer, and Dipl.-Biol. Claudia Meißner.

Intelligent catalogues

Intelligent catalogues belong to those products resulting from the close integration of knowledge management and e-commerce.

In cooperation with two industrial partners, a CD-ROM and internet software has been developed whose entire graphic information had to be derived from already existing CAD structural drawings. The result was an integrated information and ordering software showing a considerably better functionality than conventional catalogues. Different user groups are equally satisfied, e. g., by the presentation of new products to the planners by animated image sequences, and the information of technicians by detailed assembly sequences. According to the top-down structure of the software, the customer is led from the system survey to the individual product, thus acquiring detailed knowledge about the system. An interactive graphic ordering tool follows the customer's train of thought, thus facilitating a comfortable and error-free order generation.

The projects based on this system further intensify customer orientation. In the internet, interactive virtual product scenes strengthen customer loyalty, e. g., by "stories to be continued". Individual customer catalogues and a graphic presentation of offers are directed towards groups of customers and even towards individual customers. However, the most complex objective of the project is a "product system configurator", which accounts for the actual desires of customers and generates online the respective configuration proposals. These must be technically adequate and interesting from an esthetic point of view, at the same time also including bills of materials and graphic representations in photographic quality.



An intelligent product catalogue enables the user to find the desired products easily. The figure shows how the customer is led by a catalogue system developed at the Fraunhofer ITWM: he/she can see how the parts are finally assembled. In such a way, all the required parts are shown together, so that an annoying search in different product groups becomes unnecessary.

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Financial Mathematics

In the past year, modern financial mathematics has remained an actual and highly demanded area of mathematical research, practically as well as theoretically. The development of financial mathematics at the Fraunhofer ITWM also reflects this tendency.

In the last annual report, financial mathematics at the Fraunhofer ITWM still was represented by a research group of the department ADAPTIVE SYSTEMS. During the last year, current developments have been taken into account by the foundation of an individual department FINANCIAL MATHEMATICS in July, 2001. In addition to the colleagues already working in the department, four other scientists have been hired in the last year, and in 2002, two further new colleagues will join us. Hence, the expectations of the last annual report could be fully met.

The competences already existing at the Fraunhofer ITWM in all the essential areas of modern financial mathematics could be completed and reinforced considerably by the new colleagues. The main competences in the fields of derivatives, portfolio optimization, bootstrap and neural networks in financial mathematics, risk management, credit risk have thus been completed systematically by the fields of implementation of the Basle accord, methods for the pricing of convertible bonds, and option pricing in the case of stochastic volatility.

Apart from industrial projects, pure research work (i. e. not based on some contract with an industrial partner) has also been carried out during the last year. Thus, Harriet Holzberger successfully completed her PhD thesis, which was funded by an ITWM grant. Besides, new results have been proved in the field of portfolio optimization, which are reflected in papers by Holger Kraft, Martin Krekel, and Ralf Korn, meanwhile submitted for publication in international journals.

After the fast development in the last year, a consolidation phase is supposed to start in the year 2002, when the new colleagues will have joined the department as mentioned above. Apart from dealing with the actual research projects, we intend to expand the existing know-how with respect to our actual clients, as well as with respect to business consulting enterprises (especially also the small and medium-sized enterprises), a group of clients which has not been reached yet.

The members of the department are Dipl.-Math. Martin Krekel (phone: 06 31/2 05-44 68), Dipl.-Stat. Beatriz Clavero Rasero, Dipl.-Kaufm. Dipl.-Math. Holger Kraft, Dr. Gerald Kroisandt, Dr. Sergej Mikhailov, Dr. Marlene Müller, Dr. Ulrich Nögel.

Evaluation of exotic options and risk management of derivatives

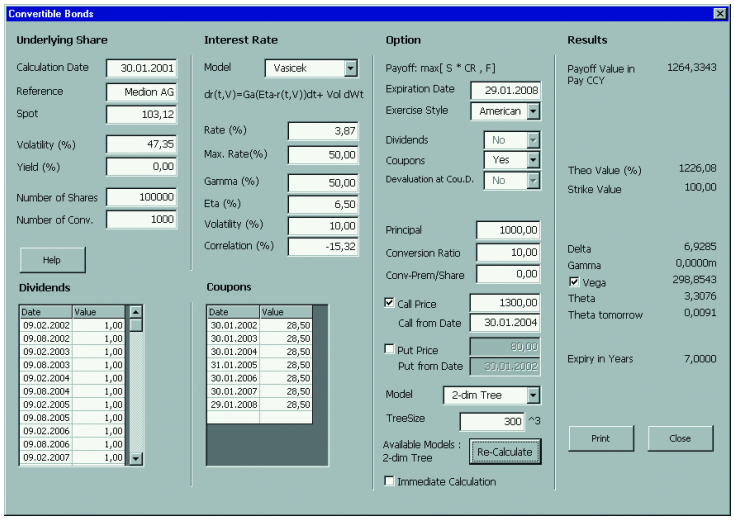
Exotic stock and credit derivatives are financial instruments whose payoff depends on the price development of the underlying asset and/or a possible bankruptcy of the respective firm. Since the beginning of the Nineties, the complexity and trade volume of these financial contracts has strongly increased, and the financial world of today cannot be imagined without them any more.

On the one hand, these derivatives are used for speculation on the market, i. e. an investor makes a bet that a special security or market sector will soon move in a certain direction. On the other hand, they are used in order to hedge positions on the market: the investor wants to adjust his/her given portfolio of securities and derivatives by buying or selling derivatives and securities in such a way that the overall value reacts unsensitively to changes of the market parameters. This is where the so-called "greeks" become important, which represent a measure for the sensitivity of the option price with respect to changes in the input parameters.

The bank portfolio consists of various securities and derivatives of different currencies, whose overall value must at least be computed once per day. Certain investment decisions have to be taken within seconds. Thus, very fast and exact methods are required for the evaluation and risk management of such a portfolio. In this area the Fraunhofer ITWM applies a wide range of methods for the analytical solution and approximation, finite differences methods, Monte-Carlo methods, as well as binomial and trinomial trees.

In the year 2001, two projects in this area were concluded successfully by the department FINANCIAL MATHEMATICS. One of the projects dealt with the examination of an existing evaluation tool of the Landesbank Baden-Württemberg, which has been improved by new algorithms. In the second project, an evaluation tool for credit derivatives has been developed in close cooperation with Amaranth Advisors, New York.

Independent research projects planned for the year 2002 belong to the fields of weather derivatives (derivatives whose payoff depends on observable weather indices) and energy derivatives (derivatives whose payoff depends on current energy prices). Both are actual research areas, and the existing results do not represent a definite market standard yet, i. e. they still have to be improved. Simultaneously, trading in weather and energy derivatives enables the respective enterprises to transfer a part of the risks to investors willing to take them. This opportunity makes trading of such derivatives increasingly attractive.



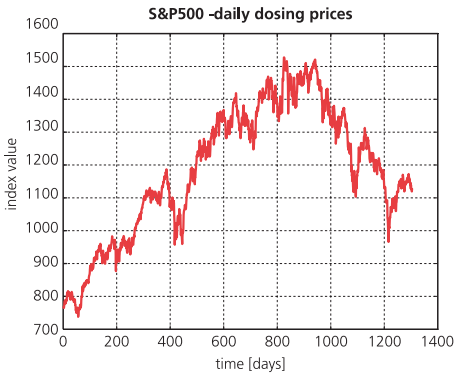
This user interface developed by the department provides the customers with a tool for the pricing of convertible bonds.

Option pricing and structures of Black-Scholes volatility surfaces

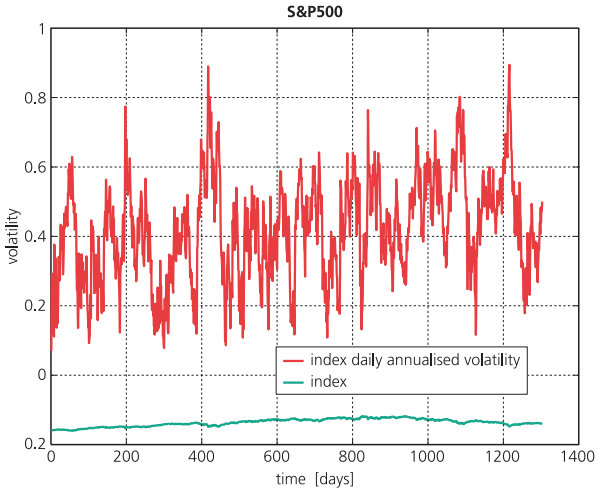
Volatility surfaces are the most important market parameters of option pricing. The GARCH model according to Heston and Nandi provides an approach which provides for a closed form solution of option prices if the volatility is not constant, thus extending the Black-Scholes model. The respective project of the Fraunhofer ITWM is highly relevant both in theory and practice.

The Heston-Nandi model is theoretically analyzed and tested in practical applications. In particular, the volatility surfaces resulting from this model are compared with those observed on the market. As a result, we expect a statement about the practical usability of the method of Heston and Nandi with respect to the computation of the Vega risk in internal models of banks.

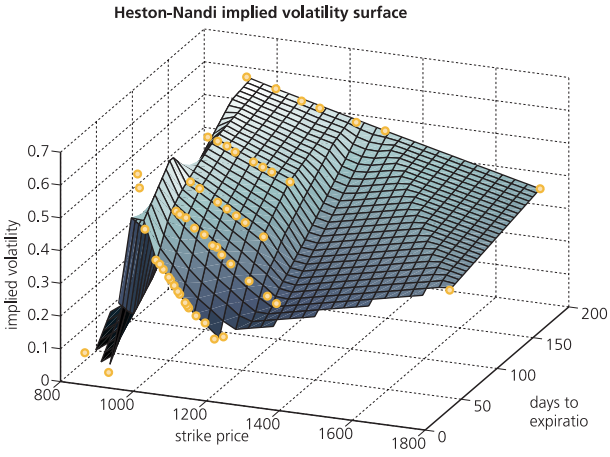
This project can be considered as the first one out of a whole series of projects in the field of option pricing in the case of stochastic volatility. The demand for know-how in this area on the side of banks and financial institutions is due to the fact that the assumption of constant volatility, on which the Black-Scholes model is based, is violated in practice. Although this insight is generally accepted, up to now no standard method accounting for this fact could be established on the market yet.



Time series of the index "S&P 500"



Computed volatility



IImplicit Heston-Nandi volatility surface for the "S&P 500" index for November 1st, 2001

Application of statistical credit risk evaluation methods

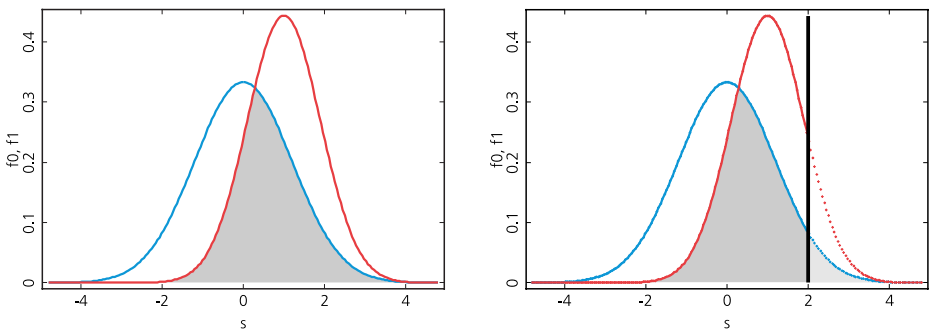
In a modern economy, financial institutions play a special role. They offer a large number of financial services to their customers and bring together investors and borrowers, which leads to a series of risks that a financial institution must be able to handle. These risks are mainly credit risks, market risks, and operational risks, which are to be underlaid with equity capital. The currently valid regulation for credit risks, which is the result of a recommendation given by the Basle Bank Supervisory Commission in 1988 ("Basle 1"), requires a constant provision of eight per cent of the standard risk-weighted credit position of a bank. Obviously, such an undifferentiated regulation is not appropriate in order to account for the actually taken risks, or to provide an optimal allocation of financial resources in an economy. Therefore, for several years now the Basle Commission has been working on a new Basle capital accord ("Basle 2"), which has been presented in January 2001, although it is currently still reviewed. The final version is supposed to be put into effect at the beginning of 2005.

This is the reason why the department FINANCIAL MATHEMATICS is supporting banks with respect to the application and implementation of the directives. In detail, the tasks are, e. g., the following:

- evaluation and comparison of existing ratings,
- design and implementation of ratings (identification and selection of driving factors, determination of an optimal weighting of the relevant factors),
- estimation of default probabilities with respect to monotony restrictions,
- selectivity analysis of credit ratings,
- backtesting and monitoring of an existing rating system.

The objective of the project is to provide the customer with a rating that is in line with the new Basle accord and facilitates a risk-adequate control of the credit portfolio.

Comparison of the risk class distributions with respect to credit losses (red) and credits payed back (blue), separated according to complete and actually observable data



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Sitting: Dipl.-Stat. Beatriz Clavero Rasero, Dipl.-Math. Arthur Harutyunyan
Not in photograph: Dr. Ulrich Nögel, Dipl.-Kfm. Dipl.-Math. Holger Kraft

High Performance Computing and Visualization

A few years ago, parallel computing almost exclusively took place in public research, meteorology, and at a small number of large enterprises. Today, the commercial use of parallel systems has also become possible due to initiatives of the European Union and the growing importance of simulation in industry. The increasing computing power of PCs and their connection in the form of PC clusters have essentially contributed to this process.

The ITWM is one of the pioneers with respect to the application of PC clusters in the case of industrial simulation problems. First systems with applications developed at the ITWM on the basis of an individual LINUX distribution were delivered to customers already in 1995. Today, the ITWM maintains a coupled system of two PC clusters with an overall number of 144 CPUs and a high-velocity network for the development of parallel software and the computation of industrial application problems. In different departments of the institute, the colleagues are working on concrete projects with respect to high performance computing and visualization.

Today, the software packages developed at the ITWM are principally prepared for parallel computer systems. Besides, existing commercial software packages are "parallelized" by order of our customers.

The research is mainly focused on

- parallel algorithms,
- dynamic load balancing,
- object-oriented software structures for parallel software, as well as
- special aspects of cluster and grid computing

Large computation problems produce large amounts of data which must be managed and analyzed efficiently. Therefore, the interactive visualization of these data is extremely important. The ITWM has developed a very fast parallel method for the volume visualization on standard PC hardware under LINUX, thus showing a possibility for the solution of the visualization problem currently caused by expensive special hardware and computer components.

In 2001, the age of grids has started for the ITWM and the Fraunhofer-Gesellschaft. In a common project coordinated by the ITWM, five Fraunhofer Institutes are developing basic grid software and establishing the Fraunhofer Resource Grid (FhRG).

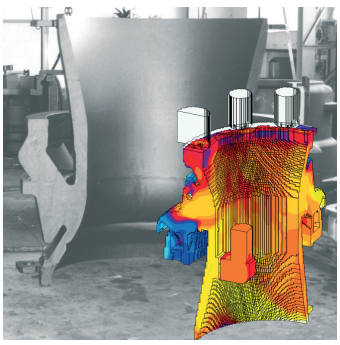
The activities in the year 2002 will be focused on the further development and extension of the basic software, as well as on a stronger integration of visualization and simulation, the development of grid applications (distributed computing on the internet), and the establishment of a grid infrastructure at the ITWM and within the Fraunhofer-Gesellschaft.

Simulation of filling processes

In cooperation with the company MAGMA Gießereitechnologie, the already existing code has been parallelized, and a completely new code for the simulation of filling processes has been developed at the ITWM (see p. 46).

A central problem with respect to the parallelization of filling process simulations is the constantly varying demand for computing power. The objective of parallelization is the distribution of the computing domain between the processors and its dynamic adaptation in order to guarantee a well-balanced utilization of computing power, and the creation of data exchange mechanisms. These three requirements have been met by a completely object-oriented design, which allows for an almost entirely automatic parallelization of applications. Mathematical optimization methods yield an optimal domain decomposition, simultaneously minimizing the necessary communication. This software library is not only applied for the simulation of filling processes at the ITWM, but also with respect to other flow dynamic codes.

The result is considerable: the computing time is now reduced from days to hours, and due to a PC cluster technology at affordable prices, this progress is also available for medium-sized enterprises.



Filling simulation in gravity diecasting as a typical example for high requirements with respect to storage and computing time: the run times in the case of one-processor workstations usually take several days.

Fraunhofer Resource Grid FhRG I-Lab project

Supported by the BMBF, five Fraunhofer Institutes have started to work on the establishment of the Fraunhofer Resource Grid FhRG. Apart from the ITWM, which is coordinating the project, these are the Fraunhofer Institutes IGD, IAO, FIRST, and SIT.

The objective of the project is to guarantee the availability of extensive hardware and software resources which are distributed globally for every institute and from everywhere as easily as possible, so that these resources can be used much more efficiently than before. Especially important are easy-to-use operation and user-friendliness. Here, the work is based on experiences with respect to the effective use of already existing software components, and with respect to the development of distributed applications.

Apart from coordinating the project, the ITWM has the task of supporting the development of the grid infrastructure within the Fraunhofer-Gesellschaft, establishing monitoring systems and a certification body, and developing grid benchmarks as well as grid applications.

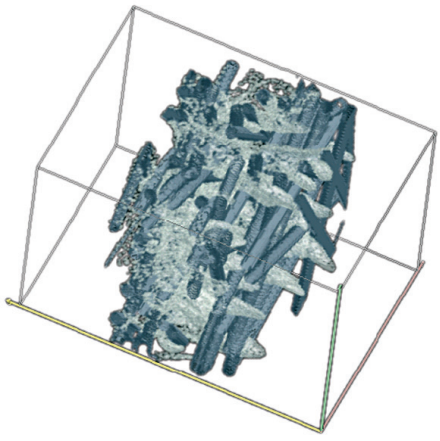
FhRG
Fraunhofer Resource Grid

Flow processes in porous materials

Multiphase flows in porous materials can be computed efficiently by the software ParPac developed at the ITWM. The periodic boundary conditions require a considerable amount of communication because the number of communicating partners strongly increases, which is problematic especially for PC clusters. Nevertheless, good scaling properties are possible with the method of chromatically ordered communication patterns (cf. annual report 1999) developed at the ITWM.

Thus, the extreme requirements with respect to computing power and storage could be met especially in the case of two-phase flows with materials of very different density. However, the computation of larger problems of microstructure analysis still goes far beyond the current capacity of the parallel computer available at the ITWM.

Visualization of a filtration process. Size of data record: 512 × 340 × 372 × 200

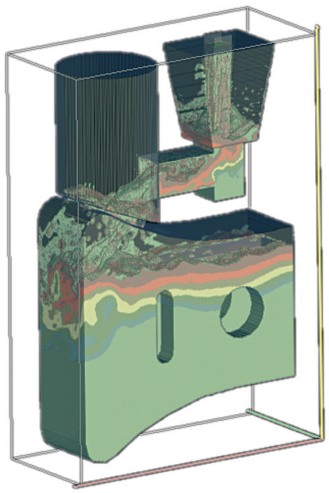


Visualization of dynamic and static volume data

The visualization of volume data by direct volume rendering methods facilitates the access to the smallest information units of the data set. This direct voxel access provides the user with a tool for a more flexible analysis of the volume data. At the ITWM, a parallel direct volume rendering method has been developed which is able to operate interactively on large, four-dimensional data records. At the current development stage of the parallel visualization method, four-dimensional data records of the dimensions 1000 × 1000 × 1000 × 100 can be visualized in color in real time. Such a high performance potential was reached by the extraction of individual core functionalities from the rendering kernel. In a second step, the individual autonomous units were examined directly and optimized for modern Intel platforms, which resulted in an essential improvement of the run time of individual process sections. Besides, the code has been parallelized, so that the algorithm is now able to run on distributed memory machines, shared memory machines, or on a mixed hardware topology. The rendering kernel itself is based on a shift method for all the variations of the algorithm. The high performance of this software-based visualization system in combination with an affordable basic hardware (PC cluster) thus also enables small and medium-sized enterprises to analyze complex data records interactively. Moreover, the method selected here can also help to save considerable resources in the fields of

- non-destructive testing,
- medical data analysis,
- visual debugging of numerical methods, and
- analysis and evaluation of simulation results

The visualization tool was presented to the international public during Supercomputer 2001 in Denver. For the year 2002, we plan the development of a visualization tool for flow dynamic applications.



Filling process simulation
Size of data record: 706 × 284 × 964 × 120

Hardware and software:

- HPC cluster: 144 CPUs
- high performance storage system: 2 terabytes
- parallel computation software: MAGMASOFT®, CFX®, FLUENT®, PERMAS®

Service offers:

- parallelization and performance tuning
- consultation with respect to the acquisition and start-up of cluster systems
- use of commercial parallel computation software
- visualization of large amounts of data

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Looking Back at the Year 2001

January 1st	Official admission to the Fraunhofer-Gesellschaft
February 6	Cooperation agreement with the "Florence Initiative for Mathematics in Industry and Management" (FIMIM)
March 9/10	Executive Committee meeting of the "European Mathematical Society" (EMS) at the ITWM
July 1st	Research group "Financial Mathematics" becomes an individual department
August 29	Foundation of the "Fraunhofer-Chalmers Research Centre for Industrial Mathematics" (FCC) in Gothenburg
October 4/5	"ECMI Glass Days" at the ITWM
October 4/5	Annual meeting of the administration managers of all Fraunhofer Institutes in Kaiserslautern
October 23	Workshop "Virtual design of open materials" at the ITWM
October 25	Fraunhofer annual meeting and "Celebration of Science" in Mainz
October 25	Presentation of the Fraunhofer Award to the research group "Microstructure Simulation"
November 21	Presentation of the Academy Award of the *Land* Rhineland-Palatinate to Prof. Helmut Neunzert
December 7	Presentation of the Innovation Award of the *Land* Rhineland-Palatinate to the research group "Analog Insydes"
December 13	Fraunhofer expert meeting "Disaster and emergency manage ment systems", organized by ITWM and IGD

Finally Fraunhofer!

Exactly on January 1st, 2001, the ITWM officially became a Fraunhofer Institute. The event, which had already been thoroughly celebrated in November of the previous year, was still worth several headlines. We can hardly believe that this was only one year ago – so fast did the ITWM feel at home in the Fraunhofer world.

Neues Fraunhofer-Institut

Das Institut für Techno- und Wirtschaftsmathematik ITWW in Kaiserslautern ist zum Jahreswechsel in die Fraunhofer-Gesellschaft eingegliedert worden. Damit erhält Rheinland-Pfalz sein zweites Fraunhofer-Institut. *DW*

Die Welt, January 3, 2001

Ein Fraunhofer-Institut für Mathematik

Das Institut für Techno- und Wirtschaftsmathematik (ITWM) in Kaiserslautern ist am 1. Januar der Fraunhofer-Gesellschaft eingegliedert worden. Es ist deren erstes Institut mit mathematischem Schwerpunkt. Zu dem Anschluß ist es gekommen, weil der Bedarf der Wirtschaft an mathematischen Forschungs- und Dienstleistungen ständig wächst. Die Arbeitsschwerpunkte des ITWM liegen in der Modellierung und Simulation von Produkten und Produktionsprozessen sowie der Qualitätskontrolle. Umfassende Erfahrungen bestehen unter anderem bei der Berechnung von Strömungen, der Simulation von Mikrostrukturen, der Bildverarbeitung, bei adaptiven, „lernenden" Systemen und bei der Optimierung von Standortplanung und Prozeßregelung. Das Institut ist Ende 1995 aus der Arbeitsgruppe Technomathematik am Fachbereich Mathematik der Universität Kaiserslautern hervorgegangen, die sich seit den frühen achtziger Jahren mit anwendungsorientierten Forschungsprojekten beschäftigt. In Kaiserslautern ist auch das Institut für Experimentelles Soft-

FAZ, January 13, 2001

Pioneer in Europe

The ITWM was one of the first Fraunhofer Institutes to act according to the recommendation of the Fraunhofer Executive Board with respect to strengthening the internationalization in Europe: in August, the "Fraunhofer Chalmers Research Centre for Industrial Mathematics", shortly FCC, was founded by the Fraunhofer-Gesellschaft and the Chalmers University in Gothenburg. This first "Fraunhofer joint venture" is coordinated by the ITWM and the Institute for Applied Mathematics in Gothenburg (more on p. 10). The exchange of scientific competence across borders and access to new markets in Europe: these are the objectives towards which the partners of the FCC have already taken large steps.

A smaller cooperation, which is, however, similarly promising, exists between the ITWM and the enterprise for technology transfer FIMIM ("Florence Initiative for Mathematics in Industry and Management") in Florence. Several common projects are already worked upon, others will follow: the basis for a "real" joint venture in Italy is increasing.

Fraunhofer ITWM
CHALMERS Research Centre Industrial Mathematics

Forscher gründen Auslands-Filiale

Kooperation mit Göteborg

▸ KAISERSLAUTERN (jüm). Das Kaiserslauterer Fraunhofer-Institut für Techno- und Wirtschaftsmathematik strebt Kooperationen mit ausländischen Partnern an. Damit soll der Forschungseinrichtung der Zugang zum europäischen Markt erleichtert werden, machte Institutsleiter Prof. Dieter Prätzel-Wolters deutlich.

Bisher am weitesten gediehen sind laut Prätzel-Wolters die Pläne mit der Chalmers-Universität im schwedischen Göteborg. Zwar seien die Verträge noch nicht unterschrieben. So viel stehe aber fest: Gemeinsam mit der Hochschule wolle das Kaiserslauterer Institut mit finanzieller Unterstützung der Münchner Fraunhofer-Zen-

Beide Partner erhalten so Zugang zu einem größeren Markt, erläuterte der Wissenschaftler die Zielrichtung. Außerdem könnten beide ihre Forschungskompetenz bei der Einwerbung neuer Projekte einbringen. Ähnliche Überlegungen gelten bezüglich der Kontakte zur Universität Florenz. Mit einer Arbeitsgruppe dieser Hochschule sei eine Zusammenarbeit vereinbart. Es werde daran gedacht, mit den Italienern in ein bis zwei Jahren zu einer ähnlichen Kooperation wie mit den Schweden zu kommen.

Die Göteborger Zweigstelle wird sich mit ähnlichen Projekten wie Kaiserslautern beschäftigen, erläuterte Prätzel-Wolters: Mit mathematischen Modellen und Simulationen, die etwa Produktionsprozesse oder Qualitätskontrollen nachbilden und so teure Experimente ersparen. Ziel sind meist Verfahrensoptimierungen. Der Wissenschaftler nennt als Anwendungsbeispiel das Gießen komplizierter Bauteile. Mit mathematischen Modellen

Die Rheinpfalz, January 3, 2001

Brilliant start for a new department

A mathematically and economically promising field for the future has been extended: the sixth department of the ITWM is completely devoted to financial mathematics. Although the projects with respect to the optimization of investment strategies will not pay off directly in cash for small stockholders, large credit institutions are provided with criteria for a realistic risk evaluation of their global financial transactions.

DER HINTERGRUND

Risikoreduktion für optimierte Anlagestrategien

Warum das Fraunhofer Institut Techno- und Wirtschaftsmathematik die Arbeitsgruppe „Finanzmathematik" gebildet hat

Von unserem Mitarbeiter Joachim Schwitalla

▸ Zinseszinsrechnung, Renten- und Tilgungsrechnung gehören zum klassischen Instrumentarium der Finanzmathematik. Im Zeitalter der Globalisierung, weltweiter Anlagestrategien und millionenschwerer Finanztransaktionen stellen Vertragspartner zunehmend hohe Anforderungen an die Risikoreduktion. Besonders beim Kauf und Verkauf von Wertpapieren will man nichts dem Zufall überlassen. Diesen Ansprüchen will die moderne Finanzmathematik Rechnung tragen. Ralf Korn, Professor für Stochastische Steuerung und Finanzmathematik an der Universität Kaiserslautern: „Die moderne Finanzmathematik ist eines der zur Zeit am stärksten bearbeiteten mathematischen Forschungsgebiete." Mit der Arbeitsgruppe „Finanzmathematik" hat das Fraunhofer Institut Techno- und Wirtschaftsmathematik der Entwicklung Rechnung getragen. Leiter der neu gegründeten Organisationseinheit ist Professor Ralf Korn.

Ralf Korn

Positive Erfahrungen haben Korn und sein vierköpfiger Mitabeiterstab in der Vergangenheit in Zusammenarbeit mit der Landesbank Baden-Württemberg in Stuttgart, der DePfa Bank in Wiesbaden und den Amaranth-Advisors in New York gesammelt. „Die den Modellen des Aktienhandels zugrunde liegende Mathematik ist neue Mathematik", betont Korn. Ein Beispiel: Bei einer Kurve aus dem Mathematikunterricht lässt sich der Verlauf durch die Steigung angeben. Das ist beim Deutschen Aktienindex durch den feinzackigen Verlauf nicht möglich. „Um ihn zu untersuchen, benötigt man spezielle Kenntnisse aus der stochastischen Analysis", weiß Korn.

Grundlage der modernen Finanzmathematik sei beispielsweise die 1973 von Black und Scholes entwickelte Formel zur Berechnung von Optionspreisen. „Ein zentrales Problem der Finanzmathematik ist die Optimierung von Anlagestrategien", erläutert er. In der Modellrechnung berücksichtigt werden auch Derivate als Alternative zum Aktienkauf sowie die Gefahr eines möglichen Aktiencrashs.

Neben der Portfolio-Optimierung liegen die Arbeitsschwerpunkte der neuen Abteilung in den Bereichen der Optionsbewertung und des Risiko-Managements. Ob asiatische oder amerikanische Optionen, wichtig sei der faire Preis einer Option. „Während der gegenüber Aktien höhere mögliche prozentuale Gewinn im Optionsgeschäft von Vorteil ist, droht andererseits der Totalverlust", meint Korn.

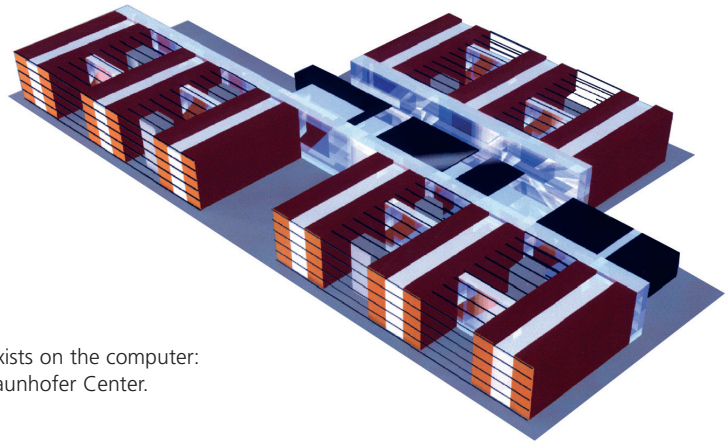
Bewertung und Neuentwicklung gelten auch den „derivativen Finanzprodukten". Sie werden unter der Bezeichnung „exotische Optionen" zusammengefasst. Zur Berechnung der Preise exotischer Derivate dienen numerische Verfahren. Der Derivatehandel habe in den vergangenen Jahren auch durch die Eröffnung der Deutschen Terminbörse in Frankfurt 1990 einen großen Erfolg verzeichnet.

Die Dienstleistung der Arbeitsgruppe Finanzmathematik schließt neben der wissenschaftlichen Beratung die entsprechende Softwareentwicklung für den Kunden ein. Korn: „Wir streben an, mittelfristig Partner für Finanzdienstleister und Unternehmensberatungen zu werden."

Indirekt profitiert auch der Privatanleger vom finanzmathematischen Know-how des Forschungsinstituts. „Finanzberatern stehen bessere Informationen zur Verfügung, der Optionshandel ist transparenter geworden, der Kunde lässt sich nicht mehr so leicht über den Tisch ziehen", bringt Korn die Vorzüge auf den Punkt.

Die Rheinpfalz, July 17, 2001

A "Fraunhofer Center" for Kaiserslautern



It already exists on the computer: the new Fraunhofer Center.

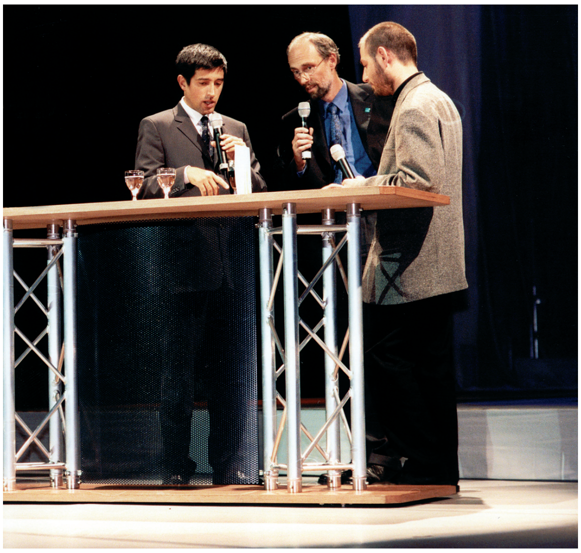
The course is set for a large Fraunhofer Center in Kaiserslautern. In the middle of the new development site "Research and Teaching", 29,000 square meters are reserved for the new building for the ITWM and the other Fraunhofer Institute IESE in Kaiserslautern. If everything works out according to schedule, the first Fraunhofer people will move to their new "home" in the spring of 2005.

Mainz in the light of the Fraunhofer-Gesellschaft

For three days, Mainz, the capital of the *Land* Rhineland-Palatinate, was the host of festivities and meetings of Fraunhofer representatives from all over the world. In the foyer of the "Rheingoldhalle", the two young Fraunhofer Institutes ITWM and IESE presented the special features of "Fraunhofer made in Rhineland-Palatinate". Four banners from floor to ceiling were the eye-catchers of the exhibition. They showed the bridges built by Fraunhofer: between "science" and "economy" and "hightech" and "trade", on a "regional" and "international" scale, constantly trying to "motivate" and "qualify" young scientists.

A lot of public appreciation:
three highly remunerated awards go to ITWM scientists

The good startof the ITWM as a new Fraunhofer member is documented by this year's presentation of the annual Fraunhofer Award to the research group "Microstructure Simulation" around Franz-Josef Pfreundt and Konrad Steiner. By using image data, the ITWM researchers determine the geometric structure of real materials in order to develop virtual models. The resulting progress for material research is the possibility of a faster and cheaper improvement of porous or textile materials (more on p. 14).



„Generationen von Studenten begeistert"

Professor Helmut Neunzert mit Akademiepreis des Landes Rheinland-Pfalz ausgezeichnet

Professor Helmut Neunzert von der Universität Kaiserslautern ist am Mittwochabend in Mainz von Wissenschaftsminister Jürgen Zöllner mit dem „Akademiepreis des Landes Rheinland-Pfalz" für vorbildhafte Leistungen in Lehre und Forschung ausgezeichnet worden.

Das Besondere des Akademiepreises - der mit 50.000 Mark dotiert ist - liege darin, so Zöllner, Leistungen in Lehre und Forschung und die Förderung des wissenschaftlichen Nachwuchses zu honorieren. Neunzert sei eine vorbildliche Persönlichkeit, die sich in allen drei Bereichen auszeichne.

Der frühere Vorsitzende des Wissenschaftsrates, Professor Winfried Schulze, sagte in seiner Laudatio, Neunzert habe neben der Grundlagenforschung die Techno- und Wirtschaftsmathematik zu einem anerkannten Teilfach der Mathematik gemacht und damit einen wesentlichen Beitrag zur Anwendung mathematischer Methoden in weiten Feldern der Wirtschaft und der Ingenieurwissenschaften geleistet. Er habe seinem Fach nicht nur die erforderliche Anerkennung verschafft, sondern aus seiner Arbeitsgruppe die Grundlagen für ein Fraunhofer-Institut entwickelt. Und er habe alles daran gesetzt, das Fach mit Begeisterung, Überzeugungskraft und hohen Maßstäben zu vertreten. Ihm sei es so gelungen, Generationen von Studenten an die Mathematik heranzuführen und sie an das Fach zu binden.

Preisträger Neunzert betonte, er begreife es als seine Aufgabe, den Studierenden zu vermitteln, dass sie nicht nur einen Beruf erlernen, sondern sich auf eine Passion einlassen. Die Studierenden sollten verstehen, dass Mathematik kein Fach zum Rausprüfen sei, sondern ein entscheidendes Element ihrer Ausbildung. Die Leute in der Wirtschaft sollten verstehen, dass Mathematik heute eine entscheidende Technologie darstelle. Die Wissensch… versteh… fe und … seien - … chische… eine er… und Le… die leb… vermit… selbst i… geister… die Beg…

„Ich befürchte, ich bin ein Macher"

Mathematikprofessor Helmut Neunzert wird mit dem ersten Akademiepreis des Landes ausgezeichnet

Von unserer Redakteurin
Claudia Schneider

Mathematik ist langweilig. Wer dies behauptet, hat Professor Helmut Neunzert noch nicht kennen gelernt. Denn wenn er von seinem Fach erzählt, ins Schwärmen gerät und Alltagsprobleme skizziert, die sich allesamt ohne die Königsdisziplin nicht lösen ließen, ist das geradezu ansteckend. Gewürdigt wird die Leistung des 65-Jährigen jetzt mit dem Akademiepreis des Landes Rheinland-Pfalz. Die Auszeichnung für vorbildhafte Leistungen in Lehre und Forschung, die mit 50.000 Mark dotiert ist, wird dem Mathematikprofessor an der Universität am 21. November in Mainz verliehen.

Der Münchner lehrt seit 1974 an der Kaiserslauterer Hochschule, sagt, das sei von Anfang an sehr reizvoll gewesen, weil man an einer jungen Uni viel mehr gestalten könne. Deshalb habe er einen Ruf sowohl nach Hamburg als auch nach Wien abgelehnt. Wegweisend war für Neunzert das Jahr 1980. Damals gründete er den Studiengang Technomathematik, mit dem Ziel, das Studium der späteren Berufswirklichkeit anzupassen. Er räumte mit dem Irrglauben auf, Mathematik finde nur im Elfenbeinturm statt und predigte ohne Unterlass: „Mathematik ist überall". Seither gilt er als Pionier, der es geschafft hat, die Mathematik in die angewandten Wissenschaften einzubetten.

Neunzert: „Es war von Anfang an mein Ziel, Probleme aus der nicht mathematischen Praxis in die Forschung aufzunehmen, Praxis und Lehre zu verzahnen." Studenten müssen beispielsweise berechnen, wie Orgelpfeifen zu formen sind, damit auch in einer Heimorgel die tiefen Töne noch stimmen, oder herausfinden, ob es auf Schildkrötenpanzern Muster gibt, an Hand derer man sie identifizieren kann. Neunzert: „Probleme der Industrie lösen wir, indem wir sie mathematisch modellieren und dann die Modelle mittels Rechner auswerten. Modellieren heiße: „Wir übersetzen in Mathematik." Wobei die Mathematik so einfach wie möglich und so komplex wie nötig sein solle.

1995 gründete Neunzert das Institut für Techno- und Wirtschaftsmathematik (ITWM), das seit Januar Fraunhofer-Institut ist. Anfangs gab es Skeptiker. Die wollten nicht glauben, dass sich mit Mathematik Geld verdienen lässt, waren aber schnell überzeugt, zumal sich Firmen aus der Region wie Heger Guss und Großunternehmen wie VW schnell vom ITWM Problemlösungen maßschneidern ließen.

Ein Verdienst Neunzerts ist es, dass sich die Universität sehr früh um internationalen Nachwuchs bemüht hat. „Ich habe schon vor 15 Jahren erkannt, dass es langfristig auch bei uns so kommen wird wie in Amerika, dass die eigenen Leute nämlich nicht ausreichen. Außerdem gibt es doch so viel Verstand auf der Welt, den man nutzen muss." Neunzert hat sich da auch privat sehr reingehängt, hat die Gäste aus dem Ausland zu sich nach Hause eingeladen, interkulturelle Wochenenden veranstaltet. „Das macht ja auch viel Spaß, mich begeistern andere Kulturen, weil sie eine Bereicherung sind." Heute kommen über 50 Prozent von Neunzerts Studenten aus dem Ausland. als es darum ging, den Studiengang „Mathematics International" einzuführen - alle Vorlesungen werden in Englisch gehalten - war Neunzert eine treibende Kraft. Auch Doppelabschlüsse sind in Kaiserslautern längst an der Tagesordnung. Dafür verbringen Studenten bis zu einem Jahr an Partner-Unis in England, Schweden oder Holland, ganz neu ist die Verbindung mit der „Scuola Normale Superiore" in Pisa.

„Ich fürchte, ich bin ein Macher", interpretiert Neunzert seinen Erfolg. Er sei eigentlich nie ehrgeizig gewesen, aber dann seien seine Projekte doch immer gut gegangen. „Vielleicht, weil ich manches etwas schneller gemacht habe als andere." Ganz wichtig ist ihm auch dieser Satz. „Ich habe an der Universität immer Menschen gefunden, die ich begeistern konnte, mitzumachen."

Privat liebt es Neunzert, der ein Blockhaus in Schweden besitzt und ein Weinberghäuschen bei Meisenheim, eher ruhig. „Ich bin kein Vergnügungsreisender." Momentan träume er davon, an einem schönen Ort zu sitzen, übers Land zu blicken und zu überlegen, wie er das Leben jetzt ordentlich zu Ende bringt.

„Mathematik ist überall": Helmut Neunzert fördert praxisorientierte Mathematik. —FOTO: VIEW

Die Rheinpfalz,
November 23/24, 2001

The Academy Award of the *Land* Rhineland-Palatinate, which was presented for the first time, went to the founder of the ITWM, Prof. Helmut Neunzert, who was honored for his "exemplary achievements" with respect to research and teaching. The jury praised him as an "excellent scholar" and a "pioneer in building the bridge between theory and applications in many areas". At the same time, Prof. Neunzert was acknowledged as an "excellent academic teacher, flexible and full of ideas in promoting his subject".

It is not only Neunzert, the former director of the ITWM, who is exemplary. The research group "Analog Insydes" received the Innovation Award of the *Land* Rhineland-Palatinate: the software of the same name which has been developed by the research group facilitates the analysis and optimization of analog circuits. A new research approach realized in a useful practical application with a wide range of possibilities - this is real innovation (more on p. 68).

Drei Preisträger aus Kaiserslautern

Innovationspreis des Landes verliehen

Bei der Verleihung des Innovationspreises des Landes für Handwerk und Mittelstand gestern in Trier fiel gleich dreimal der Name Kaiserslautern. So konnte sich die Dynetic Solutions GmbH in der Kategorie „Unternehmen" den zweiten Preis sichern, zwei Sonderpreise „Forschung" gingen an die beiden Kaiserslauterer Fraunhofer-Institute.

Die Dynetic Solutions GmbH mit Sitz im PRE-Park wurde für ihre Software „emoveo" ausgezeichnet, mit der wichtige Unternehmensinformationen mobil und in Echtzeit - beispielsweise per Handy - abgerufen werden können. Geschäftsführer Guido Moggert sagte gestern, der mit 3000 Mark dotierte Preis sei Anerkennung und Ansporn zugleich. Er sehe die Zukunft des Unternehmens sehr optimistisch, weil der Markt für mobile Unternehmenslösun… zu ermöglich… wurde das U… Jahr 2000 v… der Universitä… es beschäftigt… Mitarbeiter. W… stab vergrößer… laut Moggert… Umzug in grö… nerhalb des PRE-Par… den Kunden von Dyne… hören nach eigenen … Netzbetreiber und … gungsunternehmen.

Das Fraunhofer-Ins… mentelles Software … (IESE) erhielt einen F… ein Werkzeug für Unix-Sicherheitsrevisionen. Es soll dazu beitragen, schnell Schwachstellen aufzuspüren.

Das Fraunhofer-Institut für Techno-…

Drei Preise in die Pfalz

Auszeichnungen für Innovationen aus Kaiserslautern

TRIER (zs). Drei Innovationspreise des Landes Rheinland-Pfalz für Handwerk und Mittelstand gehen nach Kaiserslautern: Ausgezeichnet wurden gestern in Trier von Wirtschaftsminister Hans-Artur Bauckhage die Dynetic Solutions GmbH und zwei Fraunhofer Institute.

Die Firma Dynetic Solutions belegte den mit 3000 DM dotierten zweiten Platz in der Sparte „Unternehmen". Sie ermöglicht mit ihrer Software den schnellen, mobilen Zugriff auf Unternehmensdaten. Ein Sonderpreis „Forschung" und damit 2500 DM bekam das Fraunhofer Institut für Experimentelles Software Engineering. Es entwickelte „Nixe", ein Softwareprogramm, mit dem Sicherheitsmängel in einem Betriebssystem aufgedeckt werden können. Das Fraunhofer Institut für Techno- und Wirtschaftsmathematik erhielt ebenfalls einen Sonderpreis „Forschung" für ein Softwarepaket, das unter anderem zur Analyse und Optimierung analoger Schaltungen dient, die es in jedem Chip gibt.

Die Rheinpfalz, December 8, 2001

Lectures

Andrä, H., Schnack, E., Weikl, W.:
Reconstruction of interface cracks in a 3D solid body
WS Inverse Problems, University of Karlsruhe, Germany, from the 9th to the 11th of May 2001

Andrä, H.:
Simulation des mechanischen Verhaltens von Formgedächtnislegierungen
Inaugural Lecture, University of Kaiserslautern, Germany, December 13th 2001

Antonov, S., Hietel, D.:
Wechselwirkung zwischen Strömung und Strukturen
ITWM Seminar, Kaiserslautern, Germany, November 2001

Eley, M., Nieschulz, K.-P., Hilden, M., Nickel, S., Steiner, K.:
Katastrophenmanagement am Beispiel Hochwasser
2. Forum Katastrophenvorsorge »Extreme Naturereignisse – Folgen, Vorsorge, Werkzeuge«, Leipzig, Deutsches Komitee für Katastrophenvorsorge, Germany, from the 24th to the 26th of September 2001

Eley, M., Nieschulz, K.-P.:
Katastrophen- und Notfallmanagementsysteme – Ergebnisse der Fraunhofer-Expertenbefragung
Fraunhofer-Expertengespräch »Katastrophen- und Notfallmanagementsysteme«, Darmstadt, Germany, December 13th 2001

Eley, M.:
The multiple container loading problem with containers of different size
EURO 2001 Conference, Rotterdam, Netherlands, from the 9th to the 11th of July 2001

Ginzburg, I.:
Lattice Boltzmann Model for Free-Surface
Europhysics Conference, Nato Advanced Research Workshop, Cargèse, France, July 2001

Ginzburg, I.:
Application of LB method to Filling Process in Casting
GLASS Days, Kaiserslautern, Germany, October 2001

Halfmann, T., Wichmann, T.:
Weiterbildungskurs »Analog Insydes«
Infineon Technologies, Villach, Austria, October 2001

Hanne, T.:
Global multiobjective optimization with evolutionary algorithms: Selection mechanisms and mutation control
First International Conference on Evolutionary Multi-Criterion Optimization (EMO '01), Zürich, Switzerland, from the 7th to the 9th of March 2001

Hanne, T.:
Strategies for Capacity Planning in a Complex Production System
OR 2001, Duisburg, Germany, from the 3rd to the 5th of September 2001

Hietel, D.:
Mathematical Modelling and Simulation of Industrial Problems
IMAS 2001, Siena, Italy, July 2001

Hietel, D.:
NESPRI – Nebelfreies Spritzen von Außenfassaden
InnoNet-Zwischenbilanz, Berlin, Germany, September 2001

Iliev, O., Drikakis, D., Vasileva, D.:
On multigrid methods for compressible Navier-Stokes equations
3rd International Conference Large Scale Scientific Computations, Sozopol, Bulgaria, from the 6th to the 10th of June 2001

Iliev, O., Laptev, V.:
On simulation of coupled flow in plain and porous media
Joint AMS-IMS-SIAM Conference Fluid Flow and Transport in Porous Media: Mathematical and Numerical Treatment, South Hadley, MA, USA, from the 17th to the 21th of June 2001

Iliev, O., Laptev, V.:
On mathematical modeling of coupled flow in pure liquid and in porous media
3rd International Conference Large Scale Scientific Computations, Sozopol, Bulgaria, from the 6th to the 10th of June 2001

Iliev, O., Laptev, V., Reinel-Bitzer, D., Rief, S., Steiner, K., Wiegmann, A.:
Flow in porous media: Upscaling, virtual material design, industrial applications
Graduate School »Transportvorgänge in porösen Systemen der Verfahrens- und Geotechnik«, TU Bergakademie Freiberg, Germany, Wochenschule from the 5th to the 8th of November 2001

Iliev, O., Stoyanov, D. Vasileva, D.:
Flow in porous media: Challenges for computer simulation
Graduate School »Transportvorgänge in porösen Systemen der Verfahrens- und Geotechnik«, TU Bergakademie Freiberg, Germany, Wochenschule from the 5th to the 8th of November 2001

Iliev, O., Stoyanov, D.:
Effective numerical algorithms and their software implementation in the modelling of incompressible flows
Seminar of the Department of Numerical Methods, Faculty of Applied Mathematics and Informatics, Technical University, Sofia, Bulgaria, February 2001

Iliev, O., Chernogorova, T.:
A second order accurate FV discretization for a class of imperfect contact problems
3rd International Conference Large Scale Scientific Computations, Sozopol, Bulgaria, from the 6th to the 10th of June 2001

Kalcsics, J.:
Planning Sales Territories – A Facility Location Approach
GOR, Duisburg, Germany, September 4th 2001

Keck, R.:
Two-Dimensional Boundary Treatment of a Finite-Volume-Particle Method
MIT First Conferenve on Computational Fluid and Solid Mechanics, Cambridge, MA, USA, June 2001

Klein, P.:
Pressure and temperature boundary conditions in MD simulations
Workshop »Multiscale Algorithms for the Simulation of Materials and Fluids«, Imperial College, Department of Mathematics London, England, from the 2nd to the 4th of April 2001

Küfer, K.-H.:
Radiation Therapy – A Multicriteria Problem
FSRC Conferences in Applied Physics, San Diego, CA, USA, February 6th 2001

Küfer, K.-H.:
Modelling dose-volume constraints in multicriteria radiation therapy planning systems
GOR, Duisburg, Germany, September 4th 2001

Küfer, K.-H.:
MISP-Kurs Online Algorithms
University of Kaiserslautern, Germany, winter term 2000/01

Küfer, K.-H.:
Randomized Algorithms
University of Kaiserslautern, Germany, winter term 2000/01

Küfer, K.-H.:
Scheduling Algorithms
University of Kaiserslautern, Germany, summer term 2001

Kuhnert, J., Tiwari, S., Pierrot, G., Keck, R.:
Partikelmethoden am ITWM
Meshfree Methods for PDEs, Bonn, Germany September 2001

Kuhnert, J.:
Advanced Airbag Deployment Simulations
User Seminar PAM-SAFE, Detroit, USA, February 2001 und Paris, France, June 2001

Kuhnert, J.:
Airbag: Top oder Flop ?
ITWM Seminar, Kaiserslautern, Germany, July 2001

Kuhnert, J.:
Finite Poinset Method (FPM): Eine alternative numerische Methode in der Kontinuummechanik
Industrietag: Simulation spanender Fertigungsverfahren, Aachen, Germany, September 2001

Kuhnert, J.:
Finite Pointset Method (FPM): A meshfree method in continuum mechanics
Lecture at the TU München, Germany, November 2001

Linn, J.:
On the characterization of the phase space of the Folgar-Tucker equation
1st SIAM-EMS Conference »Applied Mathematics in our Changing World«, Berlin, Germany, September 2001

Melo, T.:
Facility Location in Supply Chain Design
TRISTAN IV, Triennial Symposium on Transportation Analysis, San Miguel, Portugal, from the 13th to the 19th of June 2001

Melo, T.:
Mathematical Models in Supply-Chain-Management
University of Kaiserslautern, Germany, winter term 2000/01

Melo, T.:
Linear and Network Optimization
University of Kaiserslautern (in cooperation with Dr. Anita Schöbel), Germany, summer term 2001

Mohring, J.:
Regelung nichtlinearen Lautsprecherverhaltens
ITWM Seminar, Kaiserslautern, Germany, November 2001

Neunzert, H., Werth, B.:
Mathematik in der bildenden Kunst
Österreichische Akademie der Wissenschaften, Wien, Austria, November 2001

Neunzert, H.:
Fraunhofer-Forschung in Rheinland-Pfalz
Jahrestagung der Fraunhofer-Gesellschaft, Mainz, Germany, October 2001

Neunzert, H.:
»Denn nichts ist für den Menschen als Menschen etwas wert, was er nicht mit Leidenschaft tun kann«
Lecture on the occasion of the awarding of the »Akademiepreis des Landes Rheinland-Pfalz« in Mainz, Germany, November 21st 2001

Neunzert, H.:
Die Mathematik in der Werkstoffmechanik
Ceremony colloquium held for Prof. Dr. E. Sommer, Fraunhofer IWM, Freiburg, Germany, 2001

Neunzert, H.:
Earning Money with Mathematics: A Difficult Path Between Science and Commerce
Royal Academy of Science, Edinburgh, Scotland, September 2001

Nickel, S.:
A Dynamic Two-Echelon Capacitated Location Problem with Inventory
European Chapter on Combinatorial Optimization, ECCO XIV, Bonn, Germany, from the 31st of May to the 2nd of June 2001

Nickel, S.:
Strategic Decisions in Supply-Chain-Management
OR 2001, Duisburg, Germany, from the 3rd to the 5th of September 2001

Nickel, S.:
Locational Decisions in Supply-Chain-Management
INFORMS 2001, Miami, USA, from the 3rd to the 7th of November 2001

Nickel, S.:
Recent Developments on Ordered Median Problems
Oberwolfach, December 2001

Nickel, S.:
Convex Analysis
Lecture, University of Kaiserslautern

Nickel, S.:
Scheduling
Introductory seminar course, University of Kaiserslautern

Nieschulz K.-P., Milina, J., Schilling, W., Schmitt, T.-G., Müller, M., Zimmermann, J.:
Gekoppelte Kanal- und Oberflächenströmung – Entwicklung eines EDV-Werkzeugs als Planungshilfe in Stadtentwässerung und Hochwasserschutz
2. Hannoversche Software-Tage für die Wasserwirtschaft, Technische Akademie Hannover e. V., Hannover, Germany, 27th and 28th of March 2001

Nieschulz, K.-P., Milina, J., Selseth, I., Schilling, W.:
A Proactive Approach to Flood Risk Management in Urban Drainage Systems
World Water and Environmental Resources Congress, American Society of Civil Engineers, ASCE, Orlando, USA, May 2001

Nieschulz, K.-P., Müller, M., König, A.:
Flood Risk Assessment in Urban Areas: Mathematical, Engineering and Insurance Aspects
European Geophysical Society, XXVI Assembly, Nice, France, March 2001

Nieschulz, K.-P.:
Hochwasser- und Risikomanagement im ITWM
ITWM Seminar, Kaiserslautern, October 18th 2001

Nieschulz, K.-P.:
Projektszenarien Risiko- und Hochwassermanagement
Fraunhofer Expertengespräch »Katastrophen- und Notfallmanagementsysteme«, Darmstadt, Germany, December 13th 2001

Ohser, J., Schladitz, K.:
Image analysis and mathematical morphology
University of Kaiserslautern, Germany, winter term 2000/01 and 2001/02

Ohser, J.:
Numerical Topology
2nd Wuppertal Conference on Spatial Statistics – Statistical Physics, Wuppertal, Germany, March 2001

Ohser, J.:
The estimation of the Euler number of random sets observed on point lattices
11th International Workshop on Stereology, Stochastic Geometry and related fields, Perth, Australia, December 2001

Orlik, J., Mikhailov, S.E.:
Homogenization in Integral Viscoelasticity
ZAMM 81, Suppl. 4, 983-984, 2001

Orlik, J., Mikhailov, S.E.:
Homogenization in strength and durability analysis of reinforces tooth filling
Proceedings of the fifth international symposium on computer methods in Biomechanics Biomedical Engineering held in Rome, Italy, from the 31st of October to the 3rd of November 2001

Orlik, J., Mikhailov, S.E.:
Homogenization Methods and Macro-Strength of Composites
PAMM, Proc. Appl. Math. Mech. 1 (2001)

Orlik, J., Zhurov, A., Middleton, J.:
Deriving the macrocontact condition between cementless hip-replacement and bone from the micro-geometry of the replacement coating
Proceedings of the fifth international symposium on computer methods in Biomechanics Biomedical Engineering held in Rome, Italy, from the 31st of October to the 3rd of November 2001

Pfreundt, F.-J., Steiner, K.:
Microstructure Simulation
Kimberley-Clark, Appleton / Wisconsin, USA

Praetorius, J., Halfmann, T., Wichmann, T.:
Analog Insydes: Analogschaltungsentwurf mit symbolischen Verfahren
10. E.I.S.-Workshop, Dresden, Germany, April 2001

Prätzel-Wolters, D.:
Mathematik als Schlüsseltechnologie
University of Bremen, Germany, June 2001

Reinel-Bitzer, D.:
Berechnung makroskopischer Materialeigenschaften mit Hilfe von Mikrostruktursimulationen
Workshop »Virtuelles Design offenporiger Materialien«, Kaiserslautern, Germany, October 2001

Rösch, R.:
Erkennung und Klassifizierung von Oberflächendefekten auf nichtlackierten Blechteiloberflächen
Workshop »Optische Sensoren zur Qualitätsprüfung großer Bauteile«, Magdeburg, Germany, June 13th 2001

Schladitz, K.:
Orientierungsanalyse an 3-D-Strukturen
11. Arbeitstagung »Quantitative Bildanalyse«, Darmstadt, Germany, May 2001

Schlosser, P.:
Numerical Treatment of Radiation
Glass Days 2001, Kaiserslautern, Germany, October 2001

Siedow, N.:
Industrial Problems in Glass Industry
1. SIAM-EMS Conference, Berlin, Germany, September 2001

Siedow, N.:
Some Inverse Problems from Glass
Glass Days 2001, Kaiserslautern, Germany, October 2001

Sonneborn, T.:
New Polyhedral Aspects of Hub Location Problems
European Chapter on Combinatorial Optimization, ECCO XIV, Bonn, Germany, from the 31st of May to the 2nd of June 2001 and TRISTAN IV, Triennial Symposium on Transportation Analysis, San Miguel, Portugal, from the 13th to the 19th of June 2001

Steiner, K.:
Virtuelles Design offenporiger Werkstoffe – Werkstoffauslegung mit Hilfe von Simulationen & Beispiele für Virtuelles Materialdesign
Workshop »Virtuelles Design offenporiger Materialien«, Kaiserslautern, Germany, October 2001

Steiner, K.:
Strömung in komplexen Strukturen
Workshop »Simulation technischer Prozesse«, Wiener Neustadt, Austria, January 2001

Stoyanov, D., Iliev, O.:
On a flexible 3D-multigrid solver with cell-based local refinement
3rd International Conference Large Scale Scientific Computations, Sozopol, Bulgaria,from the 6th to the 10th of June 2001

Trinkaus, H.:
Intelligent Catalogues – Integration of Content and Product Data
SSGRR 2001, International Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet, L'Aquila, Italy, from the 6th to the 12th of August 2001

Trinkaus, H.:
A Decision Support System for Selecting Optimal Radiation Therapy Plans
GOR, Duisburg, Germany, September 4th 2001

Wegener, R.:
Transportvorgänge am ITWM
Industrietag, FH Wiener Neustadt, Austria, January 2001

Wichmann, T.:
Simplification of Nonlinear DAE Systems with Index Tracking
Proc. ECCTD '01, Vol. II, Espoo, Finland, August 2001

Wiegmann, A.:
Elastostatic Design with unknown topology-requirements in 3D
Workshop »Level Set Methoden«, Lambrecht, Germany, March 22nd 2001

Wiegmann, A.:
CFD in microstructures: Ideas and applications
Applied Mathematics Department, University of Washington, Seattle, USA, June 7th 2001

Wiegmann, A.:
Structural Design via boundary motion
SIAM Annual Meeting, San Diego, USA, July 10th 2001

Publications

Andrä, H., Langhoff, T.-A., Schnack, E., Hüttinger, K.J.:
The role of back-mixing in the decomposition of methane
Fuel 80, 1273-1277, 2001

Bender, T., Hennes, H., Kalcsics, J., Melo, T., Nickel, S.:
Location Software and Interface with GIS and Supply Chain Management
Fraunhofer ITWM Reports, No. 23, 2001

d'Humières, D., Ginzburg, I., Krafczyk,M., Lallemand, P., Luo, L.-S. P., Steiner, K.:
Multi-time relaxation Lattice Boltzmann model in three dimensions. Free-Surface Lattice Boltzmann Method to Model Filling by Bingham Fluids
Philosophical Transactions of the Royal Society, March 2002

Dimitrov, A., Andrä, H., Schnack, E.:
Efficient computation of order and mode of corner singularities in 3D-elasticity
Int. J. Numer. Meth. Engng. 52, 805-827, 2001

Drikakis, D., Iliev, O., Vasileva, D.:
On Multigrid Methods for the Compressible Navier-Stokes Equations
In: Lecture Notes in Computer Science, Springer, Vol. 2179

Ewing, R., Iliev, O., Lazarov, R.:
A modified finite volume approximation of second order elliptic equations with discontinuous coefficients
SIAM J. on Scientific Computing, Vol. 23, No. 4, pp. 1334-1350

Feldmann, S., Prätzel-Wolters, D.:
Parameter Influence on the spectrum of index-2-Matrix polynominals
Appears in: Linear Algebra and its Application

Ginzburg, I., Steiner, K.:
Free surface Lattice-Boltzmann method to model the filling of expanding cavities by Bingham Fluids
Fraunhofer ITWM Reports, No. 28, 2001

Ginzburg, I.:
Introduction of upwind and free boundary into Lattice-Boltzmann method.
In: Discrete Modelling and Discrete Algorithms in Continuum Mechanics, Logos-Verlag, Berlin, Germany, pp. 97-110, 2001

Götz, T., Rave, H., Reinel-Bitzer, D., Steiner, K., Tiemeier, H.:
Simulation of the fiber spinning process
Fraunhofer ITWM Reports, No. 26, 2001

Günther, M., Klar, A., Materne, T., Wegener, R.:
An Explicit Solvable Kinetic Model for Vehicular Traffic and Associated Macroscopic Equations
Will appear in: Comp. Math. Appl.

Hietel, D., Junk, M., Keck, R., Teleaga, D.:
The Finite-Volume-Particle Method for Conservation Laws
Proceedings of the Gamm Workshop: Discrete Modelling and Discrete Algorithms in Continuum Mechanics, pp. 132-141, Logos Verlag, Berlin, Germany, 2001 and Fraunhofer ITWM Reports, No. 22, 2001

Hietel, D., Keck, R.:
Consistency by Coefficient-Correction in the Finite-Volume-Particle Method
Submitted to: Lecture Notes in Computational Science and Engineering, Springer, Berlin, Germany

Iliev, O., Stoyanov, D.:
On a multigrid, local refinement solver for incompressible Navier-Stokes equations
Mathematical Modeling, Vol.13, No. 8

Iliev, O., Stoyanov, D.:
Multigrid-adaptive local refinement solver for incompressible flows
In: Lecture Notes in Computer Science, Springer, Berlin, Germany, Vol. 2179

Iliev, O., Stoyanov, D.:
On a flexible tool for upscaling porous media flow problems
J. Theoretical and Applied Mechanics, Vol. 31, No.1, pp. 18-30, 2001

Iliev, O.:
On second order accurate discretization of 3D-interface problems and its fast solution with a pointwise multigrid solver
Will appear in: IMA Journal of Numerical Analysis

Illner, R., Stoica, A., Klar, A., Wegener, R.:
Kinetic Equilibria in Traffic Flow Models
Submitted to: Transport Theory and Statistical Physics

Korn R., Krekel M.:
Optimal portfolios with given consumption and/or income payments
Decisions in Economics and Finance

Korn, R., Kraft, H.:
Optimal portfolios with defaultable securities – a firm value approach
Review of Financial Studies

Kraft, H.:
A note on barrier derivatives with curved boundaries
Applied Mathematical Finance

Kuhnert, J., Tiwari, S.:
Finite pointset method based on the projection method for simulations of the incompressible Navier-Stokes equations
Fraunhofer ITWM Reports, No. 30, 2001

Kuhnert, J.,Tiwari, S.:
Grid free method for solving the Poisson equation
Fraunhofer ITWM Reports, No. 25, 2001

Kuhnert, J.:
Explosive Vorhersagen
Automobil Entwicklung , 4:88, mi 2001

Lang, C., Ohser, J., Hilfer, R.:
On the analysis of spatial binary images
Journal of Microscopy volume 203, pp. 303-313, 2001

Milina, J., Nieschulz, K.-P., Selseth, I., Schilling, W.:
A Proactive Approach to Flood Risk Management in Urban Drainage Systems
Urban Drainage Modelling (UDM) Proceedings, American Society of Civil Engineers, ASCE, Orlando, USA, May 2001

Neunzert, H., Siedow, N., Zingsheim, F.:
Simulation of the Temperature Behaviour of Hot Glass During Cooling
Contribution to »Mathematical Modelling: Case Studies from Industry«, Cambridge University Press, 2001

Neunzert, H.:
Die Macht der Simulation
Essay in the Annual Report of the Fraunhofer-Gesellschaft, München, Germany, 2001

Neunzert, H.:
»Denn nichts ist für den Menschen als Menschen etwas wert, was er nicht mit Leidenschaft tun kann« (Vortrag anlässlich der Verleihung des Akademiepreises des Landes Rheinland-Pfalz am 21.November 2001)
Fraunhofer ITWM Reports, No. 29, 2001

Nieschulz, K.-P., Hilden, M., Neunzert, H.:
Risikomanagement für urbane Entwässerungssysteme – Simulation und Optimierung (RisUrSim), Teil 1: Oberflächenwasser und Informationsaufbereitung (1. Teilantrag); Abschlussbericht für das BMBF – Vorhaben mit dem Förderkennzeichen 02WA0069
Fraunhofer ITWM, Kaiserslautern, Germany

Nieschulz, K.-P., Müller, M., König, A.:
Flood Risk Assessment in Urban Areas: Mathematical, Engineering and Insurance Aspects.
Geophysical Research Abstracts Vol. 3, ISSN 1029-7006

Nieschulz, K.-P.:
Ökologie und Umwelt: ΣI2255 RISURSIM: Risikomanagement von Hochwassersituationen
Eureka D-Info 4/2001, S. 1, Hrsg.: Eureka/COST – Büro im DLR, Bonn

Ohser, J., Nagel, W., Schladitz, K.:
The Euler number of discretized sets - an appropriate choice of adjacency in homogeneous lattices
in: D. Stoyan and K. Mecke: Statistical Physics and Spatial Statistics II, Lecture Notes in Physics, Springer, Berlin, Germany, 2001

Ohser, J.:
Statistical analysis of microstructures - a review of new developments
Praktische Metallographie, Vol. 38, pp. 151-168, 2001

Rave, H., Tiemeier, H., Götz, T., Reinel-Bitzer, D., Steiner, K.:
Simulation of the fiber spinning process
Chemical Fiber International, December 2001

Steinbichler, H., Nösekabel, E., Rösch, R.:
Optical inspection in the production line
Proc. Fringe, Bremen, Germany, 2001

Tiwari, S., Kuhnert, J.:
Particle Method for Simulation of Free Surface Flows
Submitted to: Journal of Engineering Mathematics

Tiwari, S., Kuhnert, J.:
Grid Free Method for Solving the Poisson Equation
Fraunhofer ITWM Reports, No. 25, 2001

Tiwari, S., Kuhnert, J.:
Finite Poinset Method Based on the Projection Method for Simulations of the Incompressible Navier-Stokes Equation
Submitted to: Lecture Notes in Computational Science and Engineering, Springer, Berlin, Germany

Tiwari, S.:
A LSQ-SPH Approach for Compressible Viscous Flows
Will appear in: Proceedings of the 8th International Conference on Hyperbolic Problems, Hyp 2000, 2001

Weikl, W., Andrä, H., Schnack, E.:
An alternating iterative algorithm for the reconstruction of internal cracks in a three-dimensional solid body
Inverse Problems 17, 1957-1975, 2001

Westphal Jr., T., Andrä, H., Schnack, E.:
Some fundamental solutions for the Kirchhoff, Reissner and Mindlin plates and a unified BEM formulation
Engng. Anal. Boundary Elements 25 (2001), 129-139

Wirsen, A., Lang, P.:
Online Monitoring of Torsional Oscillations in Rotating Machinery
AMA Proceedings International Conference Material Testing and Resarch (MAT) 2001, pp. 43 – 48, from the 8th to the 10th of May 2001

Wirsen, A., Lang, P.:
TorAn – Online Monitoring von Torsionsschwingungen und Lebensdaueranalyse bei rotierenden Maschinen
VDI-Reports 1641 Schadensverhütung bei Energie- und Industrieanalage: Monitoring-, Diagnose- und USV-Systeme, November 7th 2001

Zemitis, A,. Velten, K., Iliev, O.:
Analysis of transport processes for layered porous materials used in industrial applications
In: Mathematics as a key technology, Springer, Berlin, Germany, 2002

Zemitis, A.:
On interaction of a liquid film with an obstacle
Fraunhofer ITWM Reports, No. 27, 2001

Scientific Theses for Grading

This section contains also scientific theses in which ITWM employees were in charge for.

Amankwa, H.:
Modelling of Water Transport for Water Management in Large Catchment Areas
Magisterarbeit in »Industrial Mathematics«, University of Kaiserslautern, Germany

Atena, A. A.:
Irrigation System in a Tropical Region – A Case Study in Awassa, Ethiopia
Magisterarbeit in »Industrial Mathematics«, University of Kaiserslautern, Germany

Holzberger, H.:
Nonparametric Estimation of Nonlinear ARMA and GARCH Processes
PhD, University of Kaiserslautern, Germany

Marheineke, N.:
Modified FEM for Fibre-Fluid Interactions
Diplomarbeit, University of Kaiserslautern, Germany

Mattei, I.:
Electrical Impedance Tomography
Masterarbeit, University of Kaiserslautern, Germany

Munasinghe, J.:
Viscous Airflow Connected to a Compressed Air-shoe
Masterarbeit, University of Kaiserslautern, Germany

Rutka, V., M.Sc.:
A Fast Numerical Method for the Computation of Effective Elastic Moduli of 3D Fibrous Microstructures
Masterarbeit, University of Kaiserslautern, Germany

Stoyanov, D.:
Effective algorithms and their software implementation for incompressible flow modelling
Scientific Council in Informatics and Applied Mathematics, Bulgaria

Triebsch, L. K., M.Sc.:
A discrete Boundary Integral Approach to 3D Cell Problems with Complex Geometry
Masterarbeit, University of Kaiserslautern, Germany

von Nida, M.:
A Langrangian Method for Fracture Dynamics
Diplomarbeit, University of Kaiserslautern, Germany

Participation on Fairs and Conferences

2. Forum Katastrophenvorsorge »Extreme Naturereignisse – Folgen, Vorsorge, Werkzeuge«
Leipzig, Germany, September 2001, Poster

2. Internationaler Workshop »Risk Management in Urban Drainage Systems – Simulation and Optimization«
Trondheim, Norway, June 2001, Organization

ECMI-Glass-Days
Kaiserslautern, Germany, October 2001, Organization

Europhysics Conference; NATO Advanced Research Workshops: Upwind methods for LB methods / Effective LB simulations in porous media
Cargèse, France, July 2001, Poster

FilTech Europa, International Conference and Exhibition
Düsseldorf, Germany, October 2001, Participation

Fraunhofer-Expertengespräch »Katastrophen- und Notfallmanagement«
Darmstadt, Germany, December 2001

Fraunhofer-Jahrestagung
Mainz, Germany, October 2001, Exhibitor

Hannover-Messe Industrie
Hannover, Germany, April 2001, Exhibitor

Internationale Chemiefasertagung und -messe
Dornbirn, Austria, September 2001, Exhibitor

MAGMASOFT Anwendertreffen
Aachen, Germany, October 2001, Participation

SENSOR 2001
Nürnberg, Germany, May 2001, Exhibitor

Supercomputer 2001
Denver, USA, September 2001

Symposium und Fachausstellung »Zulieferer Innovativ«
Ingolstadt, Germany, July 2001, Exhibitor

Technologie-Transfertag der Universität Kaiserslautern
Kaiserslautern, Germany, March 2001, Exhibition

Techno-Tag der Universität Kaiserslautern
Kaiserslautern, Germany, May 2001, Exhibition

TechTextil 2001
Frankfurt/Main, Germany, April 2001, Exhibitor

Verwaltungsleitertreffen der Fraunhofer-Gesellschaft
Kaiserslautern, Germany, October 2001, Organizer

Workshop »Lattice Boltzmann Methods«
Erlangen, Germany, March 2001, Participation

Workshop »Level Set Methoden«
Lambrecht, Germany, March 2001, Organization

Workshop »Multiscale Algorithms for the Simulation of Materials and Fluids«
Imperial College, London, England, April 2001, Participation

Workshop »Virtuelles Design offenporiger Materialien«
Kaiserslautern, Germany, October 2001, Organization

Workshop on model reduction
Eindhoven, Netherlands, October 2001, Participation

Lectures Held by Guests

Angot, Prof. Ph.
University of Aix-Marseilles
Fictitious domain models of viscous flows inside fluid-porous-solid systems
April 2001

Baumbach, Dr. T., Helfen, L.
Fraunhofer-Institut für zerstörungsfreie Prüfverfahren IZP Saarbrücken
High resolution radioscopy and tomography for light materials and devices
January 2001

Berti, G.
Brandenburgische Technische Universität Cottbus
Generische Komponenten für gitterbasierte Algorithmen und Datenstrukturen
February 2001

Burkhardt, Prof. Dr. H.
Universität Freiburg
Invarianten in der Mustererkennung
March 2001

Ehrhardt, M.
Universität Saarbrücken
Diskrete transparente Randbedingungen für lineare Evolutionsgleichungen
February 2001

Hagen, Dr. T.
Technische Universität München
Erzwungene Elongation, Fadenziehen und die Gleichungen von Matovich und Pearson
June 2001

Hilfer, Dr. R.
Universität Stuttgart
Mikro-Makro-Übergang beim Transport in heterogenen Materialien und porösen Medien
June 2001

Lazarov, Prof. R.
Texas A&M University USA
Adaptive Methods for Convection-Diffusion-Reaction Equations with Applications to Flows in Porous Media
May 2001

Luo, L.
Hampton/Virginia, USA
Theory on the Lattice Boltzmann Models for Non-Ideal Gases
March 2001

Majewski, D.
Deutscher Wetterdienst Offenbach
Design und Implementierung des globalen Wettervorhersagemodells des DWD
June 2001

Margenov, S.
Bulgarische Akademie der Wissenschaften
Robust Solution Methods for Elasticity Problems
April 2001

Marin, Prof. A.
Universidad de Murcia, Spanien
Set packing problems everywhere
August 2001

Martin, Prof. A.
Technische Universität Darmstadt
Gemischt-Ganzzahlige Programmierung
February 2001

Rohde, Dr. C.
Universität Freiburg
Diffusions-Dispersions-Probleme mit Anwendungen für Phasenübergänge in kompressiblen Fluiden
June 2001

Salazar Gonzalez, J.
Universidad de La Laguna, Mexiko
Solving Travelling Salesman Problems with Pickups and Deliveries
May 2001

Saldanha-da-Gama, F.
Universität Lissabon, Portugal
Multiperiod discrete location: models and algorithms
October 2001

Schmitt, Dr. O.
Medizinische Universität Lübeck
Registrierungsmethoden biomedizinischer Bilddaten
August 2001

Sebastian, Prof. Dr. H.-J.
RWTH Aachen
Planung und Kontrolle optimaler Transportnetzwerke am Beispiel der Brieflogistik der Deutschen Post
May 2001

Steenken, D.
Hamburg
Logistische Informationssysteme im Containerumschlag
May 2001

Tamir, Prof. A.
Tel Aviv University Israel
Continuous Bottleneck Tree Partitioning Problems
September 2001

Vasileva, Dr. D.
Universität Sofia Bulgarien
On a 3D multigrid adaptive refinement solver for Non-Newtonian flow in porous media
November 2001

Werth, Prof. B.
RWTH Aachen
Mathematik in der bildenden Kunst
November 2001

Collaboration in Boards, Editorships

PD Dr. Karl-Heinz Küfer

- »Operations Research im Gesundheitswesen« team of the GOR (chair)

Prof. Dr. Helmut Neunzert

- MACSI-net, chair of Strategy Board
- Mathematical Methods in the Applied Sciences (Advisory Editor)
- Surveys on Mathematics for Industry (Editorial Board)
- European Journal of Applied Mathematics (Editor)
- Monte Carlo Methods and Applications (Editorial Board)
- Mathematical Models and Methods in the Applied Sciences (Editorial Board)
- Springer Series on Industrial Mathematics (Editor)
- Transport Theory and Statistical Physics (Editorial Board)

PD Dr. Stefan Nickel

- VDI committee of experts for simulation and optimization
- OR-Letters (expert)
- Mathematical Methods of Operations Research (expert)
- European Journal of Operations Research (expert)
- Zentralblatt für Mathematik (expert)
- Mathematical Reviews (expert)

PD Dr. Joachim Ohser

- Head of the »Quantitative Metallographie« team in the DGM committee of experts »Metallographie«
- Head of the »Digitale Bildanalyse« team in the DGM committee of experts »Metallographie«

Dr. Franz-Josef Pfreundt

- HiPC 2001 Hyderabat, member of the programme committee

Prof. Dr. Dieter Prätzel-Wolters

- ECMI – Council
- GAMM committee of experts »Dynamik und Regelungstheorie«
- MACSI-net – Executive Committee
- Speaker of the graduate school »Technomathematik« at the University of Kaiserslautern
- International Programme Committee MTNS 2002

Dr. Ronald Rösch

- VDI/VDE-GMA committee »Digitale Bildverarbeitung in der Automatisierungstechnik«
- VDI/VDE-GMA committee »Software und Softwarequalität in der Messtechnik«
- Fraunhofer Network »Vision«

Dr. Norbert Siedow

- Organizator of the »MACSI-Glass« working group
- MACSI-net Newsletter (Editor)

Dr. Raimund Wegener

- MACSI-net Newsletter (Editor)

Patents

Ginzburg, I.:
Lattice-Boltzmann-Verfahren zur Berechnung von Strömungsvorgängen mit freien Oberflächen
European application for a patent, 01112597.6, 2001

Trinkaus, H., Küfer, K.-H.:
Ein Navigationswerkzeug zur Ermittlung effizienter Strahlentherapiepläne
German application for a patent, October 2001