Johann Radon Institute for Computational and Applied Mathematics

AUSTRIAN ACADEMY OF SCIENCES

Annual Report 2007

PERIOD:	1.1.2007- 31.12.2007
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Content

1. INTRODUCTION

This report has been compiled by the Institute Director Heinz W. Engl based on input by all group leaders and all members of the Institute. It is a report both to the Austrian Academy of Scienes and to the newly created Scientific Advisory Board. Because of the latter purpose, the development of the Institute since its creation is also shortly outlined, although the main emphasis is on achievements in 2007. Information on the previous years is contained in the annual reports about the years 2003 – 2006, which are available to the members of the Scientific Advisory Board on request and can also be found on the Institute hompage www.ricam.oeaw.ac.at. This report contains:

- General information on the development, current status and future plans of the institute, also in comparsion with the proposal submitted to the Austrian Academy of Sciences which was the basis of founding the Institute. This part also contains an overview over personnel development since 2003, and over the development of internal and external funding. Finally, this part contains a statement by the Institute Director about his personal view concerning the Institute leadership structure in the foreseeable future.

- Reports about the scientific achievementsof the groups and institute members for the the year 2007, and plans for 2008 and 2009, structured in the same way as the annual reports

- A complete list of RICAM publications for the year 2007.

2. THE DEVELOPMENT OF THE INSTITUTE IN GENERAL

2.1 THE MISSION

The founding of the Institute was the outcome of a lengthy discussion process in the Austrian Academy of Sciences, which had several stages and especially involved the submission of a formal proposal in 2001. The aims contained in the proposal can be summarized in the following formal "mission statement" of the Institute:

Mission Statement

The Johann Radon Institute for Computational and Applied Mathematics (RICAM)

- does basic research in computational and applied mathematics according to highest international standards
- obtains the motivation for its research topics also from challenges in other scientific fields and industry
- emphasizes interdisciplinary cooperation between its workgroups and with institutions with similar scope and universities world-wide
- cooperates with other disciplines in the framework of special semesters on topics of major current interest
- wishes to attract gifted PostDocs from all over the world and to provide an environment preparing them for international careers in academia or industry
- cooperates with universities by involving PhD-students into its research projects
- promotes, through its work and reports about it, the role of mathematics in science, industry and society

In order to achieve these goals, the original proposal aimed at

- establishing five research groups
- a total of 25 PostDocs funded via basic funds
- funds for holding one "Special Semester" each year.

Keys elements of the proposal were:

- international recruiting of PostDocs
- PostDoc positions should be strictly limited by 6 years, with an initial contract of normally 3 years and an extension based on achievement
- the aim to be able to fund at least one position for a doctoral student per PostDoc from external funds, mainly via FWF projects.

The last two points were connected: One requirement for PostDocs, which would play a role in a decision about extending their contracts, would be success in acquiring external research funding. The motivation for this was twofold: first, it should of course increase the funding base for the Institute. But secondly, it was also thought of as training for PostDocs in a skill required in their future careers.

We think we achieved the goals set in the application, as documented below and in the previous annual reports. However, as explained below, we considered it necessary to deviate from the original strategy in some aspects: this concerns both the group structure and the policy of having only fixed-term positions.

2.2 THE RESEARCH GROUPS: DEVELOPMENT, PLANS

Based on the proposal, the following groups were established in 2003:

- Computational Methods for Direct Field Problems, led by Prof. Ulrich Langer
- Inverse Problems, led by Prof. Heinz Engl
- Financial Mathematics, led by Prof. Gerhard Larcher and Prof. Walter Schachermayer
- Symbolic Computation, led by Prof. Bruno Buchberger and Prof. Josef Schicho
- Analysis of Partial Differential Equations, led by Prof. Peter Markowich and Prof. Christian Schmeiser

Of these group leaders, Prof. Buchberger, Engl, Langer and Larcher were Professors at JKU (Johannes Kepler Universität Linz), while Profs. Markowich, Schachermayer and Schmeiser were based in Vienna. During the initial year, Prof. Schmeiser took a partial leave of absence from TU Vienna and was half-time employed at RICAM, so that all groups were led at least partially by "local" researchers. This was quite important for the initial phase of the Institute for making joint strategic decisions, for setting up cooperations between the groups, and also for integrating the Institute into JKU. The situation has changed since then:

Prof. Buchberger, who had already retired from his professorship at JKU (but remains highly active in research), gave up his position as RICAM group leader on Sept. 30, 2006, after having led a highly successful Special Semester on "Gröbner Bases". The transition to a new group leader was smooth,

since Prof. Schicho, who had been employed by RICAM (being on leave from RISC, the world-renowned Research Institute for Symbolic Computation at JKU) had already been deputy group leader and took over the leadership from Prof. Buchberger, who still cooperates with RICAM via an FWF project (F1322) jointly led with Prof. Engl.

The situation in the Financial Mathematics Group was a bit more problematic: This group was originally established also for the purpose of being able to take over some researchers of a previsous institute of the Academy, which had been closed following the departure of its head, Prof. Niederreiter, to the National University of Singapore. These researchers had been working on quasi-Monte-Carlo methods, so that it was very welcome that the group leadership was originally shared by Prof. Larcher, who had just been appointed to the Financial Mathematics Chair at JKU and had also worked on QMC methods, and by Prof. Schachermayer of TU Vienna, an expert in stochastic finance with scientific and personal connections to Linz. This worked smoothly for some time until Prof. Larcher decided that he wanted to concentrate on other activities and asked to be released of his RICAM duties. After a short search, we were lucky to be able to attract Prof. Albrecher (then TU Graz) as group leader (joint with Prof. Schachermayer). We chose the same arrangement as originally with Prof. Schmeiser: Prof. Albrecher took a part-time leave from TU Graz and was appointed half-time at RICAM. This arrangement was in force until September 2007 (see below for the current situation). Since the appointment of Prof. Albrecher, the group was partially restructured, both by new research directions for the scientists already in the group and by hiring (also using third-party funds) additional staff. Prof. Albrecher currently has an offer to a full professorship in Hannover and will undoubtedly get more offers in the future. As a result of this offer, the Academy appointed him to a permanent position, connected with a part-time professorship at the Johannes Kepler Universität Linz (see Section 2.3).

We had originally also planned to establish a group on Computational Logic to be headed by Prof. Gottlob, then TU Vienna. Since he has, in the meantime, moved to a Chair at the University of Oxford, we have currently abandoned this plan. However, we were able to attract two more renowned Austrian applied mathematicians to leading groups at RICAM in Linz:

Since July 2004, Prof. Karl Kunisch (University of Graz) leads a group “Optimization and Optimal Control“.
Since October 2006, Prof. Otmar Scherzer (University of Innsbruck) leads a group on “Mathematical Imaging”.
The addition of these groups was in both cases preceded by a formal proposal which was approved by the Advisory Board (“Kuratorium”).

In 2007, the leadership situation has changed significantly due to the facts that Prof. Markowich has assumed a Chair at the University of Cambridge (and still keeps a part-time appointment at the University of Vienna) and that Prof. Engl has been appointed Vice Rector for Research at the University of Vienna for a four-year period starting October 1, 2007; for this period, he is on leave from the Johannes Kepler Universität Linz, but is still Institute Director. Based on the experience so far, we consider this not ideal, but manageable (see Section 2.8). But certainly, in the long run, the leadership structure in Linz has to be strengthened, also via additional links to JKU (see Section 2.3).

Thus, the current situation is that three groups are led by “local” scientists (Profs. Albrecher, Langer and Schicho), and the remaining groups are led by researchers based in Vienna, Graz and Innsbruck, respectively. However, it has to be emphasized that these group leaders spend time in Linz regularly and that all group members are based in Linz. Prof. Engl’s contract at the University of Vienna explicitely allows him to spend one day per week in Linz.

There are plans for new groups, which does not necessarily imply the need for additional basic funding:

- a "transfer group" for building links to industry will be established, as already discussed with the Advisory Board (see Section 2.7)
- there are concrete plans for establishing a group on "Mathematical Methods in Molecular and Systems Biology" which will at least partially be based in Vienna; these plans are highly welcomed by the directors of two large bioscience institutes of the Academy based in Vienna, Profs. Penninger and Superti-Furga, and by members of the life sciences faculties at the University of Vienna. A cooperation with the Fraunhofer Society (via a group to be established in Vienna by ITWM Kaiserslautern) is planned. The resulting "joint group" (factually, note legally; the cooperation will be institutionalized via a cooperation agreement between the Academy and the Fraunhofer Society) will be a key element in larger plans for decievely strengthening the computational biology scene in Vienna.

The scientific plans of the seven existing groups can be found in the corresponding chapters in this report. In addition to their own work, the groups will further strengthen their scientific cooperation. The cooperations between the groups that led to joint publicatiuons form a connected graph, but not a complete one (which is not necessarily an aim). Due to the fact that there is a quite large turnover in scientific staff, we constantly have to work to keep the spirit of cooperation between groups alive. One vehicle are our Radon Colloquia and Seminars (see Section 3.5). It has to be mentioned, however, that the current situation that the groups are housed in separate buildings is not ideal for cooperation. We hope that the plans of JKU to complete the second stage of the "Science Park" buildings where RICAM and the mathematical institutes of JKU will be housed can be realized in the proposed time frame. The first stage is already under construction.

In addition to internal cooperations, all groups have intensive cooperations world-wide as can be seen from the individual reports. This is supported by the fact that we have access to considerable travel and guest scientist funds.

2.3 SCIENTIFIC PERSONNEL

As indicated in the last annual report, the year 2007 is again a year of expansion of personnel towards the final size of the institute of about 60 scientists as planned. With December 31, 2007, RICAM employed 39 scientists with a doctorate and 19 doctoral students; of those, 13 PostDocs and 19 doctoral students were employed by via external funds. Thus, with December 31, 2007, RICAM had 58 scientific employees, 32 of them being externally funded. For 2008, our aim is to reach the planned state of 30 PostDocs funded via basis funds (Academy of Sciences and Upper Austrian Government).

The following scientist left in 2007:

Name	**Employed until**	**Left to**	**Position**
Lukas Neumann	31.01.2007	University of Vienna	University Assistent
Martin Giese	28.02.2007	JKU - RISC	Research Scientist
Arnd Rösch	31.03.2007	University of Duisburg-Essen	Full Professor
Shun-Yin Chu	30.04.2007	Hongkong	Research Scientist
Almedin Becirovic	30.04.2007	Fronius International GmbH	

Dylan Copeland	31.05.2007	JKU – Numerics Institute	Research Scientist
Marco Discacciati	31.05.2007	Ecole Polytechnique Fédérale Lausanne	Research Scientist
David Pusch	31.05.2007	Private Company	
Svetlana Cherednichenko	30.06.2007	University of Duisburg-Essen	Research Scientist
Klaus Krumbiegel	30.06.2007	University of Duisburg-Essen	Research Scientist
Klaus Scheicher	01.10.2007	BOKU Vienna	Research Scientist
Lin He	31.12.2007	UCLA	Research Scientist
Gottlieb Pirsic	31.12.2007	University of Linz	Research Scientist
Hanna Pikkarainen	31.12.2007	Technical University of Helsinki	Research Scientist

In 2007, the following additional PostDocs were hired via RICAM basic funds:

PostDoc Name	**At RICAM since**	**Doctorate: year, institution**	**Came to RICAM from**
Corina Constantinescu	01.01.2007	2006, Oregon State University	Oregon State University
Xiliang Lu	15.07.2007	2006, National University of Singapore	National University of Singapore
David Sevilla Gonzalez	01.08.2007	2004, University of Cantabria	Concordia University, Montreal
Jean-Francois Renaud	01.08.2007	2007, University of Montreal	Université de Montreal
Chokri Chniti	01.09.2007	2005,Ecole Polytechnique	INRIA, France
Sergiy Pereverzyev jun.	01.09.2007	2006, Technical University of Kaiserslautern	Technical University of Kaiserslautern
Jenny Niebsch	15.10.2007	2001, University of Bremen	Konrad Zuse Institut and MathConsult

The following PostDocs and doctoral students were hired in 2007 via external funds:

PostDoc Name	**At RICAM since**	**Doctorate: year, institution**	**Came to RICAM from**
Eva Sincich	01.01.2007	2005, SISSA/ISAS, Trieste, Italy	INRIA, Sophia Antipolis, France
Domingo Gomez	01.02.2007	2003, University of Cantabria	University of Spain
Marcin Janicki	01.09.2007	1999, Technical University of Lodz	Technical University of Lodz

Doctoral Student Name	**At RICAM since**	**Diploma: year, institution**	**Project: agency/number/leader**
Philip Ngare	01.03.2007	University of Nairobi	Austrian Exchange Service, Albrecher
Martin Bernauer	20.08.2007	JKU	FWF, P19918, Griesse

Szilvia Bela	01.09.2007	2007, Budapest University of Technology and Economics	FWF, SFB F1315, Schicho
Erwin Karer	01.09.2007	JKU/TU Eindhoven	FWF, P19170, Kraus
Clemens Zarzer	01.09.2007	JKU/TU Eindhoven	WWTF Project, Engl
Xinghua Song	15.10.2007	University of Science and Technology of China	SFB, 1315, Schicho
Stephan Anzengruber	21.11.2007	University of Linz	FWF, P19029, Ramlau

As can be seen from this list and the corresponding lists in the previous annual reports, there is a large turnover in scientific personnel. We succeed in recruiting researchers from all over the world, which might be seen as an indicator of the reputation RICAM has obtained. Our researchers are quite successful in getting attractive, mostly tenure-track or tenured positions elsewhere.

The following scientists got offers for professorships:

Name	**Professorship at**	**Status**
Joachim Schöberl	RWTH Aachen	Accepted April 2006
Arnd Rösch	University of Duisburg-Essen	Accepted April 2007
Martin Burger	University of Münster	Accepted October 2006
Hansjörg Albrecher	University of Hannover	currently negotiating
Roland Griesse	Technical University of Dresden RWTH Aachen Technical University of Chemnitz	Accepted offer of Chemnitz, will leave on March 1,2008
Boris Vexler	University of Mainz University of Bonn University of Stuttgart Technical University of Munich	Accepted offer of Munich, will leave on March 1,2008

However, in spite of being an indicator that the Institute is successful in preparing individuals for scientific careers, which is one of its aims, it is also problematic to lose scientists at such an accelerating rate. Currently, due to our policy of strictly limited time contracts, we have no possibility of making "counter offers": Our current policy still is to hire scientists only on non-permanent positions: usually for three years, extendable for another three years. Within the Austrian Academy of Sciences, an employment of six years in total is the maximum which is possible for non-permanent positions. In order to obtain a more stable personnel structure, we will slowly relax this policy and offer a few (very few!) permanent positions. This will be done only for people of exceptional high quality on the scientific level of professors (e.g., for group leader positions). In that case, the current group leaders might withdraw from leading their groups on a daily basis to the position of a scientific advisor. We are negotiating with JKU some kind of joint appointments, where, in addition to a permanent position with a salary on professorial level funded at least 75% by the Austrian Academy of Sciences, the University will appoint the respective people as professors (with a low teaching obligation, but with the possibility to teach, thus enabling them to advise doctoral and diploma students) and pay 25% of the salary. In this way, RICAM will be more closely linked to the University, thus, on the one hand, having easier access to local students and, on the other hand, influencing the development of mathematics at the University of Linz. After initial talks between the JKU Rector, the President of the Austrian Academy of Sciences and the Institute Director in late 2006, a formal agreement has been signed in 2007. The first realization of this strategy has been the appointment of Prof. Albrecher to a professorship in Insurance Mathematics at the Johannes Kepler Universität (on a 25% basis) and his simultaneous appointment to a permanent position by the Academy. Due to legal reasons, the appointment at the University is for 2 years; the next step for the University is to get a permanent position into the "development plan" (a procedure which involves the rectorate, the senate

and the university council and is hence time consuming). This position then has to be advertised and eventually filled via the usual university procedures. Our aim in this procedure is to keep Prof. Albrecher as group leader in Linz. Since October 1, Prof. Albrecher is also Deputy Director of the Institute (in addition to Prof. Langer, replacing Prof. Markowich).

2.4 THE ADVISORY BOARDS

According to the rules of the Academy valid until the end of 2007, the Institute had a "Kuratorium" (Advisory Board). Its role was mostly advisory, but it also had some executive duties like approving the budget (a-priori and a-posteriori), the research program and the group structure.
In some of the Academy institutes, these advisory boards were composed mostly of Austrians, who are full members of the Academy. In our case, this board had, from the beginning, a strong international component. Its members were:

Prof. Dr. Karl Sigmund, Universität Wien (Chairman)
Prof. Dr. Hans Troger, Technische Universität Wien (Vice-Chairman)

Prof. Dr. Franco Brezzi, Università degli Studi di Pavia
Prof. em. Dr. Curt Christian, Vienna
Prof. Dr. Dr.h.c. Peter Deuflhard, Konrad-Zuse-Zentrum Berlin
Prof. Dr. Peter M. Gruber, Technische Universität Wien
Prof.em. Dr. Dr.h.c.mult. Edmund Hlawka, Vienna
Prof. Dr. Dr.h.c. Rolf Jeltsch, ETH Zürich
Prof. Dr. Dr. h.c. Herbert Mang, Technische Universität Wien
Prof. Dr. Harald Niederreiter, National Universtity of Singapore
Prof. Dr. Dr.h.c. Helmut Neunzert, ITWM Kaiserslautern
Prof. Dr. Olivier Pironneau, Université Pierre et Marie Curie - Paris-6
Prof. Dr. Ludwig Reich, Universität Graz
Prof. Dr. William Rundell, Texas A&M University
Hofrat Dr. Herbert Saminger, Government of Upper Austria
Dr. Daniel Weselka, Federal Ministry for Science and Research

The board had one meeting per year (around Easter). The Friday meetings contained the formal agenda points like budget, but also scientific progress reports by the Institute director and the group leaders. In the afternoon, we always asked one of the foreign members to give a scientific talk. The formal meeting was preceded by more detailed scientific presentations by junior members of three research groups on Thursday afternoon.

The meetings were well attended, especially by the foreign members. The discussions at the meetings and also at the informal parts were always very valuable to us.

According to a new legal structure at the Academy, this board will be replaced in 2008 by a Scientific Advisory Board, which will be composed exclusively of foreign members (in addition to representatives of the Federal and Upper Austrian Governments) and which will have slightly different duties. Its membership was not yet known when this report was prepared.

2.5 AWARDS, PUBLICITY

Prof. Peter Markowich is winner of the Royal Society-Wolfson Research Merit Award 2007. This is one of the Royal Society's most prestigious awards given to individuals of proven outstanding ability to undertake independent, original researchat a UK research institution (since September 2007, he is Professor at the University of Cambridge).

Prof. Heinz Engl is joint winner (with Ingrid Daubechies, Princeton University) of the ICIAM Pioneer Prize, established for "pioneering work introducing applied mathematical methods and scientific computing techniques to an industrial problem area or a new scientific field of applications". The prize is funded by SIAM and was awarded in a ceremony at ICIAM 2007 in Zürich:

Shuai Lu and Hui Cao advised by Prof. Sergiy Pereverzyev were awarded by Chinese Government such an award for outstanding PhD-students abroad (300 persons from all branches of science worldwide received such award endowed with 5000 USD).

In 2004, Dr. Arne Winterhof won the Hlawka Preis of the Austrian Academy of Sciences.

In 2006, Prof. Hansjoerg Albrecher won the IWAP Travel Award of the IMS (Institute of Mathematical Statistics).

In 2007, Prof. Albrecher was awarded a research prize by the Styrian Government.

These awards and other events like meetings and special semesters were always a welcome opportunity for press releases. There were frequently articles in local and national media, mainly in the respected daily newspaper "Der Standard" about scientific activities at RICAM. Also, the local radio station carried a one-hour interview with the Institute director, which created a lot of favourable reactions among the general public.

The University also included RICAM into its public relations strategy, several news pieces about RICAM appeared in the JKU media.

Finally, RICAM and IMCC (see next Section) created and jointly financed a DVD about their work; this was done by a professional agency and mailed to many Austrian opinion leaders in science, industry, media and politics and also to colleagues abroad. This DVD was well received (as also letters by members of the Federal Government including the Finance Minister indicated) and certainly contributes (together with frequent reports about our work in newspapers) to the positive image applied mathematics has in Austria. The DVD is available to the members of the Scientific Advisory Board.

2.6 RICAM AND MATHEMATICAL SCIENCES IN LINZ

The previous Rector Rudolf Ardelt and administration of JKU have been very supportive. RICAM had the opportunity to rent office space and lecture halls at and via JKU, and has been supported e.g. by the respective administrative departments in planning and buying furniture, network infrastructure and renovation work. Also, RICAM and JKU have a contract about library use: RICAM can use the large holdings of the JKU library and can invest especially into buying new monographs to a larger extent than JKU would be able to; thus, this agreement is beneficial to both sides.

Scientifically, the cooperation between RICAM and JKU is less developed than originally expected. The University has "Computational Science and Engineering" as a major field in its strategic development plan, and RICAM could play a major role. However, so far, JKU did not allocate funds to really invest into this field. And cooperations between RICAM and the mathematical institutes at JKU are nearly exclusively restricted to those institutes whose professors are group leaders in RICAM. We expect that the establishment of joint positions as mentioned in Section 2.3 will improve this situation.

Another organization that is active in applied mathematics in Linz is the Industrial Mathematics Competence Center (IMCC), which cooperates with industry in joint projects co-funded by the industrial partners and government support via the current K-ind-program. This funding is currently available until the end of 2008. The only current formal link to IMCC is via Prof. Engl, who is also scientific director of IMCC. From 2009, the K-ind-program of the Austrian government will be replaced by a program called COMET. In 2006, IMCC applied for funding in that new program as a "K1 center" with RICAM as the scientific partner. The reports of the scientific referees were very good (as far as can be judged from the excerpts available), but the proposal was rejected; one of the main reasons given for this was that "there is no direct cooperation between the industrial partners, cooperation arises only via similar mathematical methods". The government agency FFG which administers the COMET program advised to re-apply in the next call for "K-projects", which is another (a bit smaller) funding line. IMCC will certainly follow this advice, again with RICAM as scientific partner. Also for this purpose, a "transfer group" will be established at RICAM. Funding obtained from the Upper Austrian Government for 2008 – 2011 is partially dedicated to that purpose.

2.7 THE FUTURE LEADERSHIP STRUCTURE OF THE INSTITUTE

This content of this section is strictly the personal opinion of the current institute director, Prof. Heinz Engl, which is also indicated by the use of personal pronouns like "I" and "me":

In early 2007, I was (to my surprise) offered the position of Vice Rector for Research (and 1st Deputy Rector) of the University of Vienna. After some thought (and also consultation with the Academy President, Prof. Peter Schuster, and the Chairman of the RICAM Advisory Board, Prof. Karl Sigmund) I accepted this position for a 4-year period starting on October 1, 2007. During that time, I will be on unpaid leave from my JKU professorship.
My contract with the University of Vienna allows me to remain director of RICAM and to spend one day each week in Linz. Also, the University of Vienna provides some office space for RICAM close to my Vienna office, so that RICAM scientists and visitors can spend some time in Vienna if needed e.g. for cooperation with me. Already now, the directorship of RICAM was *beside* another full time position, namely a professorship in Linz. The only, but certainly relevant, differences to the future situation will be that my new full time position will be in Vienna, which is 90 minutes by train from Linz, and will of course offer fewer synergies with the RICAM directorship than a JKU professorship. But, on the other hand, I will travel considerably less to conferences and stays at foreign universities, so that the total time and energy directly useable for RICAM may not be much less than before.
I feel able and willing to serve as RICAM director for another 3-year-period beyond my current contract, which ends on December 31, 2008, although it will certainly require more effort and create more stress than giving up this position. But, of course, I feel responsibility for what I helped to build up.
An additional problem is that one of the deputy directors, Prof. Markowich, has moved to Cambridge. Since in the course of this move, he resigned as Deputy Director (but fortunately keeps his role as a co-group-leader), the Academy appointed Prof. Albrecher to Deputy Director. Thus, the current directorate contains again 2 members which are full time in Linz, as it was the case previously.

In addition, Drs. Pereverzyev and Ramlau could assume some kind of leadership positions, at least in the Inverse Problems Group. Both have been quite successful also in acquiring third party funds, and Dr. Ramlau has been appointed to a 2-year professorship at JKU replacing me there temporarily. Altogether, this would certainly be a workable solution until the end of 2011. I want to mention that it will also have some advantages for RICAM that I have more presence in Vienna, both scientifically and "politically".

2.8 THE EVALUATION OF THE INSTITUTE

In 2007, i.e., four years after its creation, the Institute was evaluated by an international committee on behalf of the Academy. The Academy had formed a joint committee for the evaluation of this Institute and for that of the Institute for Quantum Optics and Quantum Information (Innsbruck/Vienna) which consisted of the follwing members:

- Prof. Dr. Wolfgang ERTMER
  University of Hannover
  Institute of Quantum Optics

- Prof. Dr. Dr. h.c. Wolfgang HACKBUSCH
  Max Planck Institute for Mathematic in the Sciences
  Scientific Computing

- Prof. Dr. Gerd LEUCHS
  University Erlangen-Nuremberg
  Institute of Optics, Information and Photonics (Max Planck Research Group)

- Prof. Dr. Alfred K. LOUIS
  Saarland University
  Institute for Applied Mathematics

- Prof. Dr. Wolfgang SCHLEICH
  University of Ulm
  Institute of Quantum Physics

- Prof. Dr. Harry YSERENTANT
  Technical Univesity of Berlin
  Institute of Mathematics

The members received a written report similar to this one and visited the Institute on October 23, 2007.

2.9 IT-INFRASTRUCTURE

Network at Aubrunnerweg premises

The new premises at Aubrunnerweg are fitted with both 1000Mbit and 100Mbit network. Each workplace is fitted with at least one 1000Mbit and one 100Mbit wall socket. The workstations are connected together with 1000Mbit network to allow fast access for cluster operation. The 100Mbit network is available for Laptops. The same network sub segment is used in all RICAM locations to provide access between all RICAM computers and servers. All premises are fitted with wireless LAN access points. The wireless LAN access points are integrated into the WLAN infrastructure of University of Linz to allow the wireless network usage on the whole university campus without reconfiguration of the clients.

Central Firewall

The Hardware of the Firewall which was replaced completely on warranty last year was working flawlessly this year except one hard disk failure. The failed hard disk has caused no downtime as the hard disks are running in redundant mode. The firewall software has been reinstalled because of software configuration troubles caused by the hardware change last year.

Servers

Computing Server 1:
A dedicated 4-Way Dualcore CPU (8 CPUs total) Computing Server with 64GB of main memory available to all RICAM employees for large calculations and development of parallel processing software was bought. Gentoo Linux is installed as operating system. Matlab, Mathematica and Maple are installed as scientific mathematics software. For calculations, the Computing Server can be reserved for exclusive access if needed. The new computing server
is located at the Aubrunnerweg premises.

Computing Server 2:
The dedicated dual Processor Computing Server with 8GB of main memory bought in 2005 was working well as expected. Additional software was added if requested. SuSE Linux is installed as operating system. Matlab, Mathematica and Maple is installed as scientific mathematics software. For calculations, the Computing Server can be reserved for exclusive access if needed.

To be able to run more than one matlab instance, a matlab network license was bought for both our computing servers.

Communication server:
The server provides the RICAM web page including database access, email access through POP3 and IMAP, Spam and virus filter for email services, web mail access, groupware scheduler, mailing list manager, and CVS repository. The operating System is Linux with extra access control kernel patches to add an extra security layer. All used software (except the virus scanner) is open source and free for use. Many installed programs where updated to a recent version. For the Special Semester on Quantitative Biology analyzed by Mathematical Methods, extra web pages and database-based scripts for information, registration, program, and time schedules were written.

At the end of 2007 it was decided to buy new hardware for the communication server. With the institute constantly growing, it would no longer be possible to handle the amount of data with the current hardware.

It was decided to buy 2 identical servers to build a high-availability (HA) solution. The current server will be split into small independent virtual server parts which will be able to migrate between the 2 physical servers in case of failure. The high-availibility setup will be based on Hardened Gentoo Linux, XEN virtualization, heartbeat HA software for migration of the xen based virtual machines and DRBD for synchronization of the filesystem.
For extra security SELinux policies will be configured for all virtual machines. If new services are needed, new virtual machines can simply be added without the need of new hardware.

File Server:
The file server allows centralized user management and data storage for Windows and Linux Clients. Each user can access her or his data from any client in the network with both Linux and Windows clients. Data are backed up during every night to the central backup server owned by the Johannes Kepler University. The operating system is Linux with extra access control kernel patches to add an extra security layer. All used software is open source and
free for use.
In 2007, a new raid-array with total 3TB of Space was bought as nearly no space was left at the old 800GB raid-array. The new raid-array is divided into 2 partitions, a 1.8TB partition for backup of the workstations and a 1.2TB partition for user data.
Many installed programs at the fileserver where updated to a recent version.

Terminal server:
The terminal server allows access to Windows applications on Linux through the rdesktop client. The operating system is Windows2003 Server with Terminal Services licensed. In 2007, no changes where made to the configuration as everything is working well. Many installed programs were updated to a recent version.

Clients

Laptops:
Fujitsu Siemens E Laptops were bought for the best compromise between mobility and power. Each laptop is equipped with 2 GB memory extension to reach better performance for calculations and a DVD burner + USB flash memory for data exchange. Both Linux and Windows are installed as operating systems. MS Office is also usable under Linux with the help of the CrossOver Office Windows emulator. Matlab, Mathematica and Maple are installed as scientific mathematics software for both Windows and Linux as needed.

Workstations:
No new workstations where bought this year as there are currently enough workstations available for RICAM employees. During summer all Workstations where updated to a recent version of SuSE Linux. Microsoft applications (mainly Microsoft Word and Powerpoint) can be used through the Windows 2003 Terminal Server which was bought in 2004. The workstations are able to work in a cluster mode with parallel programmed applications. Matlab, Mathematica and Maple are installed as scientific mathematics software as needed.

3. SPECIAL SEMESTERS, CONFERENCES, COLLOQUIA

3.1 SPECIAL SEMESTERS, GENERAL INFORMATION AND PREVIOUS EVENTS

Already in the proposal, Special Semesters played an important role in justifying the need for such an institute in Austria. This was based on the experience various group leaders had with such events at institutions abroad. E.g., the Institute director led a Special Semester on Inverse Problems at the Institute for Pure and Applied Mathematics at UCLA in 2003 and participated in similar events in Berkeley (MSRI), North Carolina (SAMSI) and Cambridge (Newton Institute).

So far, the following Special Semesters have been conducted:

- Fall of 2005: Special Semester on Compuational Methods in Mechanics, main organizer: Prof. Ulrich Langer, see report 2005

- Spring of 2006: Special Semester on Gröbner Bases, main organizer: Prof. Bruno Buchberger, see report 2006.

- October 2007 – January 2008: Special Semester on "Quantitative Biology Analyzed by Mathematical Methods"; see below for detailed information.

As already indicated in the proposal, special semesters need not be conducted by group leaders of RICAM in all cases, (main) organizers could also be solicited from outside. In the future, also calls for proposals will be issued. Of course, in all cases, topics for special semester will have a strong overlap with the scientific expertise at RICAM.

In the fall of 2008, we will have a first case of a special semester whose main organizer comes from outside RICAM. Prof. Wolfgang Runggaldier (University of Padova) chairs the organizing committee of a "Special Semester on Stochastics with Emphasis on Finance", see below.

For the spring of 2009, we are planning a special semester on some aspects of inverse problems, one of the organizers will be Prof. Bernd Hofmann (Chemnitz) who plans to spend a sabbatical at RICAM. This semester should fit into an international string of events like an inverse problems year at Hokkaido University in 2009/10, a possible inverse problems semester at MSRI (Berkeley) in 2010 and a program at the Newton Institute in Cambridge proposed for 2011. The RICAM event will culminate in the large "Applied Inverse Problems" conference scheduled for July 20 – 24, 2009, at the University of Vienna, chaired by the Institute Director. The previous conference of this bi-annual series were held in Montecatini, Lake Arrowhead (UCLA), Cirencester (UK, organized by UCL), and Vancouver (UBC), the Institute director was involved in all of these conferences either as invited speaker or as committee member.

3.2 SPECIAL SEMESTER ON QUANTITATIVE BIOLOGY ANALYZED BY MATHEMATICAL METHODS, OCTOBER 1, 2007 – JANUARY 27, 2008

This special semester on Quantitative Biology analyzed by Mathematical Methods took place from October 1, 2007 until January 27, 2008. http://www.ricam.oeaw.ac.at/ssqbm/

Program Committee
Robert Anderssen, CSIRO Mathematical and Information Sciences, Canberra, Australia
Martin Burger, University of Münster, Germany
Vincenzo Capasso, University of Milan, Italy
Robert Eisenberg, Rush University and Argonne National Laboratory, Chicago IL, USA
Heinz W. Engl, RICAM, Austria (Chair)
Christoph Flamm, University of Vienna, Austria
Philipp Kügler, RICAM & Johannes Kepler University Linz, Austria
Ulrich Langer, RICAM & Johannes Kepler University of Linz, Austria
Peter Markowich, RICAM & University of Vienna, Austria
Peter Pohl, Johannes Kepler University Linz, Austria
Otmar Scherzer, RICAM & Leopold Franzens University of Innsbruck, Austria
Christian Schmeiser, RICAM & University of Vienna, Austria
Peter Schuster, University of Vienna, Austria

The following workshops were held:

Workshop on Ion Channels, October 8-12, 2007

Organizers
Martin Burger, University of Münster, Germany
Robert Eisenberg, Rush University and Argonne National Laboratory, Chicago IL, USA
Heinz W. Engl, RICAM
Peter Pohl, Johannes Kepler University Linz, Austria

Workshop Abstract
Channels control the flow of many substances into and out of cells and are of enormous importance in health and disease. Channels and transporters make up a large fraction of all the proteins in the human body and are studied experimentally by thousands of molecular biologists. Many of the drugs used by physicians act on channels, and their structure is known with atomic resolution. Ion channels work by switching between open and closed states. In the open state, they have a structure that does not change significantly on a time scale relevant for simulations. Ions move through the open channel by electrodiffusion controlled by the density of permanent and polarization charge on the channel protein, and the shape of the hole in the channel. The driving forces for ion movement are concentration gradients and the electrical potential across the channel protein. The movement of ions through the channel can be described by the Poisson-Nernst-Planck equations. Selectivity of membrane channels is, in part, achieved by size exclusion, in particular in water channels. In the limiting case, pores are so narrow that water molecules and ions cannot pass each other. So far little is known about water mobility in confined pores, and it is an important task to obtain further insight by quantitative mathematical models and simulations.

Speakers & Talks:
Kattrin Arning, RICAM
Talk: Inverse Problems related to Ion Channels
Jaydeep Bardhan, Argonne National Laboratory, USA
Talk: Forward and Inverse Problems in Protein Modeling I
Dezso Boda, Rush University Medical Center, USA
Talk: Monte Carlo simulations of ion channels: dealing with dielectric boundaries and efficient phase space sampling
Steve Cox, Rice University, USA
Talk: Inverse Problems in Neuronal Calcium Signaling
Robert Eisenberg, Rush University and Argonne National Laboratory, USA
Talk: Devices for Atomic Control of Macroscopic Transport
Dirk Gillespie, Rush Medical University, USA
Talk: Ion selectivity in the ryanodine receptor and other calcium-selective channels
Clemens Heitzinger, University of Vienna, Austria
Talk: Modeling BioFETs, an emerging nano-biosensor technology
Douglas Henderson, Brigham Young University, USA
Talk: Energy and entropy: the yin and yang of physical and biological science
Peter Hinterdorfer, University of Linz
Talk: Single Molecule Recognition Force Microscopy
Gerhard Hummer, National Institutes of Health, USA
Talk: Water, proton, and ion transport: from nanotubes to proteins
Dmitry Karpeev, Argonne National Laboratory, USA
Talk: Spatial Inhomogeneities and Sensitivities in Coupled Ion Channels-Baths Systems
Gernot Kieseritzky, Free University Berlin, Germany
Optimizing pKA computation in proteins with pH adapted conformations
Ernst-Walter Knapp, Free University Berlin, Germany
Talk: Exploring electron, proton and ion transport in proteins computationally.
Matthew Knepley, Argonne National Laboratory
Talk: Computational Tools for Electrostatics
John Lowengrub, University of California, USA
Surface phase separation and flow in models of multicomponent vesicles
Maria Neuss-Radu, University of Heidelberg, Germany
Talk: A multiscale approach to ion transport through channels
Wolfgang Nonner, University of Miami, USA
Talk: From ion channels to ion transporters
Peter Pohl, Johannes Kepler University Linz, Austria
Talk: Water in membrane channels
Roland Roth, Max Planck Institute for Metals Research, Germany
Talk: Can hydrophobically lined channels be gated by water?
Zuzanna Siwy, University of California, USA
Talk: Anomalous Mole Fraction Effect, Gating, and Rectification in a Large Diameter Abiotic Nanopore
Thomas Weikl, Max Planck Institute of Colloids and Interfaces, Germany
Transition states in protein folding and function
Marie-Therese Wolfram, RICAM
Talk: Numerical Simulations of Ion Channels using Finite Elements

Workshop on Systems Biology, November 5 - 9, 2007

Organizers
Heinz W. Engl, RICAM
Christoph Flamm, University of Vienna, Austria
Philipp Kügler, RICAM & Johannes Kepler University Linz, Austria
Peter Schuster, University of Vienna, Austria

Workshop Abstract
Systems biology is heading for a description of the functional relations of all players in an entire cell or an organism by means of chemical reaction kinetics, i.e., complete genetic and metabolic reaction network are the subject of mathematical analysis, modeling, and simulation. Although analysis and modeling of whole cells is still out of reach, modules or semi-autonomous regulation and reaction subnetworks are studied successfully and provide an understanding of important quantities which are characteristic for living systems, e.g., robustness, homeostasis and long term stability of periods. The great challenge of systems biology comes from the large numbers of reactions, often several thousands and more, as well as a similarly large number of parameters, many of which are unknown, leading to high dimensional ODEs. High-throughput data of cells at the genomic, proteomic and metabolic levels provide an enormous amount of information on the dynamics of functioning cells. During the special semester we focus on mathematical methods to infer the functional network at genomic or metabolic level from such time series data. Problems to be studied include the calcium dynamics during T-cell activation, the analysis of stoichiometric networks and the evolution of metabolic networks.

Speakers & Talk:
Bree Aldridge, Massachusetts Institute of Technology, USA
Talk: Perturbing and Analyzing the Dynamics of Apoptosis in Single Cells
Jaydeep Bardhan, Argonne National Laboratory, USA
Talk: Forward and Inverse Problems in Protein Modeling II
Paul Barton, Massachusetts Institute of Technology, USA
Talk: Global Dynamic Optimization and Mixex-Interger Dynamic Optimization
Luca Cardelli, Microsoft Research Cambridge, UK
Talk: Representing Biochemical Systems as Collectives of Interacting Automata
Attila Csikasz-Nagy, University of Trento, Italy
Talk: Mathematical Models of Cell Cycle Regulatory Networks
Hidde De Jong, INRIA Rhône-Alpes, France
Talk: Qualitative simulation of the carbon starvation response in Escherichia coli
Willy Govaerts, Ghent University, Belgium
Talk: MatCont: A numerical bifurcation tool for modeling.
Markus Hegland, Australian National University, Australia
Talk: On the numerical solution of the master equations for gene regulatory networks
Mats Jirstrand, Fraunhofer-Chalmers Research Centre for Industrial Mathematics, Sweden
Talk: Parameter estimation in biochemical systems using prediction error minimization
Edda Klipp, Max Planck Institute for Molecular Genetics, Germany
Talk: Modeling of Yeast Cell Stress Response
David Kreil, University of Natural Resources and Applied Life Sciences, Austria
Talk: Expression profiling by microarrays: Experiments and Analysis
James Lu, RICAM
Talk: Inverse analysis for qualitative aspects of gene networks
John Lu, National Institute of Standards & Technology, USA
Talk: Metrology and Robust Statistical Methods for High Throughput Biological Measurements at Cellular and System Levels
Julie Mitchell, University of Wisconsin-Madison, USA
Talk: Recursive Motifs in Metabolic Networks
Martin Moennigmann, Aachen University of Technology, Germany

Talk: Constructive Nonlinear Dynamics – Application to a tryptophan biosynthesis model
Stefan Müller, RICAM
Talk: Parameter identification in systems biology: solving inverse problems using regularization
Antonis Papachristodoulou, University of Oxford, UK
Talk: Methods and Algorithms for Biological Networks Analysis
Peter Schuster, University of Vienna, Austria
Talk: From biochemical kinetics to systems biology
Stefan Schuster, Friedrich-Schiller-University Jena, Germany
Talk: Metabolic Games - A Game-Theoretical Approach to Studying the Evolution Biochemical Pathways
Bruce Shapiro, The Beckman Institute at Caltech, USA
Talk: Developmental Modeling of the Shoot Apical Meristem
Peter Sykacek, BOKU University, Austria
Talk: Bayesian Modelling of Shared Gene Function: Methods Development and Benchmarking
Bruce Tidor, Massachusetts Institute of Technology, USA
Talk: Structure–Function Relationships in Biological Network Models
Katharina Wilkins, Massachusetts Institute of Technology, USA
Talk: Sensitivity Analysis of Biological Oscillators: Structure-Function Relationships in the Mammalian Circadian Clock Network
Jason Zwolak, Virginia Tech, USA
Talk: PET: A Tool for Estimating Rate Constants in Models of Molecular Networks

Workshop on Bioimaging I, November 12 - 16, 2007

Organizer
Otmar Scherzer, RICAM & Leopold Franzens University of Innsbruck, Austria

Workshop Abstract
The goal of imaging is to make data accessible for efficient visual inspection. Today imaging is a multidisciplinary field, with profund applications in medicine, computer vision, biology, industry, and in general in applied sciences. Imaging is performed on every scale; on the top end is astrophysics where it is used to analyze huge objects such as galaxies. In radiology, current technological developments aim to improve the detection of disease. Novel measurement devices are developed to enhance resolution and to make imaging techniques applicable for visualization of smaller details with particular applications in the bio sciences.
During the program we study mathematical methods and applications of imaging in the bio sciences. In particular, we focus on mathematical methods for image reconstruction, image filtering, novel applications for data acquisition, visualization and mathematical theory.

Speakers & Talks
Mark A. Anastasio, Illinois Institute of Technology, USA
Talk: Inverse source concepts applied to photoacoustic tomography
Simon Arridge, University College London, UK
Talk: Diffuse Optical and PhotoAcoustic Tomography
Ben Cox, University College London, UK
Talk: Optical Inversions in Photoacoustic Imaging
Stanislav Emelianov, University of Texas at Austin, USA
Talk: Integrated Ultrasound, Elasticity, and Photoacoustic Imaging
Jerome Fehrenbach, Universite Paul Sabatier - Toulouse III, France
Talk: Conductivity Imaging using Electrical Impedance Tomography and Elastic Deformation
David Finch, Oregon State University, USA
Talk: Sound and Light Show: Mathematics and Photoacoustic Tomography
Martin Frenz, University of Bern, Switzerland

Talk: Optoacoustic imaging using a linear transducer array: simulations and experiments
Markus Haltmeier, University of Innsbruck, Austria
Talk: Photoacoustic tomography and the inversion of the circular Radon transform
Michael Klibanov, University of North Carolina at Charlotte, USA
Talk: Some numerical methods and theoretical results for inverse problems
Richard Kowar, University of Innsbruck, Austria
Talk: Estimation of 3-dimensional transducer pressure fields from Schlieren data
Peter Kuchment, Texas A&M University, USA
Talk: On recent mathematical results in thermoacoustic imaging
Leonid Kunyansky, The University of Arizona, USA
Talk: New reconstruction formulas and algorithms for problems of thermoacustic tomography
Pierre Maréchal, Université Paul Sabatier (Toulouse 3), France
Talk: Regularizing the inverse of truncated Fourier operators
Mohamed Masmoudi, University Paul Sabatier, France
Talk: Medical imaging by elastography
Joyce McLaughlin, Rensselaer Polytechnic Institute, USA
Talk: Algorithms, Approximations and Images for Tissue Shear Stiffness Imaging
Frank Natterer, University of Münster, Germany
Talk: Reconstruction methods in ultrasound tomography
Günther Paltauf, University of Graz, Austria
Talk: Three-dimensional photoacoustic tomography using optical line detection of ultrasound
Sarah Patch, University of Wisconsin-Milwaukee, USA
Talk: Causality & Acoustic Attenuation in Thermo/Photo/Opto-Acoustic Imaging
Thomas Schuster, Helmut Schmidt University, Germany
Talk: Lambda sonar tomography for unbounded centersets
Lihong Wang, Washington University in St. Louis, USA
Talk: Photoacoustic tomography: structural, functional, and molecular imaging of biological tissue

Workshop on Bioimaging II / PDEs, November 19 - 23, 2007

Organizers
Arjan Kuijper, RICAM
Peter Markowich, RICAM & University of Vienna, Austria
Otmar Scherzer, RICAM & Leopold Franzens University of Innsbruck, Austria

Workshop Abstract
Partial differential equations (PDEs) take a prominent role in image analysis and processing. They can be obtained as the Euler-Lagrange equations from models that describe an optimal situation, e.g. energy, in combination with certain constraints.
On the other hand, PDEs can be designed to create a process that enhances structures, like edges, or removes noise.
In this workshop the state of the art of PDE approaches is presented and recent developments are discussed in the specific context of bioimaging.

Speakers & Talks
Werner Benger, Louisiana State University, USA
Talk: Visualizing Neuronal Structures in the Human Brain via Diffusion Tensor MRI
Bernhard Burgeth, Saarland University, Germany
Talk: PDEs for Processing Tensor Fields (II)
Yunmei Chen, University of Florida, USA
Talk: A Local Nonparametric Model for Simultaneous Image Segmentation and Adaptive Smoothing
Rachid Deriche, INRIA, France
Talk: Diffusion MRI Processing : Models and Algorithms from Images to White Matter Fibers

Peter Elbau, RICAM
Talk: Non-convex variational methods
Claudia Frohn-Schauf, Heinrich-Heine-University Duesseldorf, Germany
Talk: Nonlinear image registration using variational PDE methods – different models and solution techniques
Bastian Gebauer, RICAM
Talk: Localized potentials in electrical impedance tomography
Oliver Gloger, Technical University Berlin, Germany
Talk: A Threestepped Coordinated Level Set Segmentation Method for Extracting Atherosclerotic Plaques from MR-Images
Lin He, RICAM
Talk: MR Image Reconstruction from Sparse Radial Samples by Using the Iterative Refinement Procedure
Atsushi Imiya, Chiba University, Japan
Talk: Dynamic Classification of Volumetric Cardiac Optical-flow using Variational Constraints.
Stephen Keeling, University of Graz, Austria
Talk: Generalized Rigid Image Registration and Interpolation by Optical Flow using Contrast Invariant Intensity Scaling
Ron Kimmel, Technion - Israel Institute of Technology, Israel
Talk: Isometry in Biometry
Frank Lenzen, University Innsbruck, Austria
Talk: A PDE Method for Filtering Vector-Valued Data
Karol Mikula, Slovak University of Technology, Slovakia
Talk: Numerical methods for large-scale 3D image sequence analysis
Jan Modersitzki, University Lübeck, Germany
Talk: Numerical Treatment of Landmark Constrained Image Registration
Nikos Paragios, Ecole Centrale de Paris, France
Talk: Metric-Free Dense Image Registration Using Primal/Dual Principles and Efficient Linear Programming
Talk: Robert Plemmons, Wake Forest University, USA
Integrated Computational Lenslet Array Systems Applied to Bioimaging
Talk: Ronny Ramlau, RICAM
Simultaneous segmentation and reconstruction of tomography data
Martin Rumpf, University of Bonn, Germany
Talk: A Rudin Osher Fatemi Approach to Optical Flow
Alessandro Sarti, University of Bologna, Italy
Talk: On the subriemannian structure of the primary visual cortex
Xue-Cheng Tai, University of Bergen, Norway
Talk: Using TV-Stokes equations for digital image denoising and restoration
David Tschumperle, GREYC, France
Talk: Processing of diffusion MRI datasets using variational tools and PDEs.
Joachim Weickert, Saarland University, Germany
Talk: PDEs for Processing Tensor Fields (I)

Workshop on Biomechanics and Chemotaxis, December 10 - 14, 2007

Organizer
Ulrich Langer, RICAM & University of Linz, Austria
Peter Markowich, RICAM & University of Vienna, Austria
Christian Schmeiser, RICAM & University of Vienna, Austria

Workshop Abstract

Many fundamental processes in our body depend on the ability of cells to migrate - examples range from embryogenesis and wound healing to the response of our immune system to infections or the generation of new blood vessels. The crawling motion of cells has first systematically been described more than two decades ago and, since then, it has become a field of intensive research. Especially in the last years, the development of new experimental methods and tools has allowed to gain new insights into the biological, chemical and mechanical nature of cell migration. However, due to the complexity of the processes involved, biologists are still far away from having a complete picture of how cells move. During the special semester we want to use mathematical modelling in an interdisciplinary fashion for getting a deeper understanding of the observed biological phenomena as well as for providing tools to test different hypotheses and theories formulated by experimentalists. In particular, there will be a focus on the intracellular biomechanical effects and their interplay with the intracellular biochemistry and with the mechanical properties of the environment. One emphasis will be on a mechanical description of the dynamics of the cytoskeleton, in particular the growth, decay, and mechanical response of polymer networks. Experiments elucidating the exact structure of the cytoskeleton will be analyzed as well as experiments on the behaviour of living, crawling cells.

Modelling and simulation of chemotaxis is a success story of Mathematical Biology. On the one hand, prototypical mathematical models like the Keller-Segel model have been investigated thoroughly with many exciting mathematical results. On the other hand, an ongoing modelling effort deals with the incorporation of effects on the individual cell level as well as with alternative transport models for cell ensembles. In the framework of the special semester, the nonlinear interaction between cells caused by long range (signalling) and short range (adhesion) effects and the consequent mathematical difficulties (e.g. blow-up in finite time) will be investigated. Furthermore, quantitatively accurate models for applications such as immune response, vasculogenesis, embryogenesis will be derived and analysed. The multiscale (cell vs. ensemble scale) nature will be crucial both from an analysis and from a numerical point of view. We plan to establish an interaction with experimental biologists, leading to experiment-driven modelling and systematic parameter identification by methods for inverse problems.

Speakers & Talks

Mark Alber, University of Notre Dame, USA
Talk: Continuous macroscopic limit of a discrete stochastic model for interaction of living cells
Keith Anguige, RICAM
Talk: A one-dimensional model of cell diffusion and aggregation, incorporating volume filling and cell-to-cell adhesion
Peter Arbenz, Swiss Federal Institute of Technology, Switzerland
Talk: A Scalable Multi-Level Preconditioner for Matrix-Free μ-Finite Element Analysis of Human Bone Structure
Igor Aronson, Argonne National Laboratory, USA
Talk: Onset of collective behavior in colonies of swimming microorganisms
Piotr Biler, University of Wroclaw, Poland
Talk: Self-similar solutions of a parabolic system of chemotaxis
José Antonio Carrillo, Autonomous University of Barcelona, Spain
Talk: The critical case of the Patlak-Keller-Segel system
Fabio Chalub, Universidade Nova de Lisboa, Portugal
Talk: Models for genetic evolution in large populations
Jon Chapman, Oxford University, UK
Talk: Discrete and continuum models for growth of biological tissue
Lucilla Corrias, Université d'Evry Val d'Essonne, France
Talk: The global existence theory and blow-up for the Keller-Segel model of chemotaxis
Jean Dolbeault, Université Paris Dauphine, France
Talk: The two-dimensional Keller-Segel model after blow-up
Zdenek Dostal, Technical University Ostrava, Czech Republic
Talk: Fast algorithms for quadratic programming with applications to biomechanics
Radek Erban, University of Oxford, UK

Talk: Stochastic modelling of reaction, diffusion and taxis processes in biology
Jan Haskovec, University of Vienna, Austria
Talk: Stochastic particle approximation to the global measure valued solutions of the Keller-Segel model in 2D
Christian Hellmich, Vienna University of Technology, Austria
Talk: Universal' microstructural patterns in bone and wood: Micromechanics-based prediction of stiffness and strength from chenical composition and hierarchical microstructure
Gerhard Holzapfel, Royal Institute of Technology, Sweden
Talk: Computational aspects in soft tissue mechanics with a focus on the cardiovascular system
Anita Kettemann, University of Stuttgart, Germany
Talk: Mathematical modeling of chemosensitive cell dynamics in multidimensional tissue networks
Axel Klawonn, University of Duisburg-Essen, Germany
Talk: Computational Aspects of Arterial Wall Simulation
Ralf Kornhuber, Free University Berlin, Germany
Talk: First steps towards the human gait
Martin Kroon, Royal Institute of Technology, Sweden
Talk: Estimation of material properties of hyperelastic inhomogeneous anisotropic membranes by inverse analysis
Svetozar Margenov, Bulgarian Academy of Science, Bulgaria
Talk: Parallel PCG algorithms for voxel elasticity systems with application to micro-FEM analysis of bones
Peter E. McHugh, National University of Ireland, Ireland
Talk: Non-linear finite element methods in biomechanics: from the single cell to the organ level
Maya Neytcheva, Department of Information Technology, Sweden
Talk: Large scale numerical simulations of bone structures using iterative methods
Dietmar Ölz, Vienna University, Austria
Talk: A model for the Actin-cytoskeleton in the Lamellipodium of living cells
Kevin Painter, Heriot-Watt University, UK
Talk: The role of cell and matrix interactions in cellular guidance.
Benoit Perthame, Ecole Normale Supérieure, France
Talk: Kinetic formulations and the hyperbolic Keller-Segel system
Gernot Plank, The Johns Hopkins University, USA
Developing Virtual Heart Simulators - A computational framework to solve the Cardiac Bidomain Equations
Oliver Sander, Free University Berlin, Germany
Talk: Multidimensional Coupling in a Human Knee Model
Robert Scheichl, University of Bath, UK
Talk: Robust Coarsening for Multiscale PDEs
Jonas Stålhand, Linköping University, Sweden
Talk: Mechanical modelling of smooth muscle contraction in arteries
Triantafyllos Stylianopoulos, University of Minnesota, USA
Talk: Structure-based, Mechanical Modeling of Soft Biological Tissues
Christina Surulescu
Talk: A nonparametric approach to cells dispersal
Pascal Verdonck, Ghent University Hospital, Belgium
Talk: The role of Fluid-Structure Interaction for Medical Device Design
Zhian Wang, University of Alberta, Canada
Talk: Pattern formation from a volume filling chemotaxis model
Christian Wieners
Talk: Parallel numerical methods for a porous media model in biomechanics
Zohar Yosibash, Ben-Gurion University, Israel
Talk: Reliable p-FE analysis of the proximal femur validated by in-vitro experiments
Jorge Zubelli, IMPA, Brazil
Talk: On the Inverse Problem for a Size Structured Model

Workshop on Pattern Formation and Functional Morphology, January 7 - 11, 2008

Organizer

Robert Anderssen, CSIRO Mathematical and Information Sciences, Canberra, Australia
Vincenzo Capasso, University of Milan, Italy

Workshop Abstract

A fundamental question in Biology, Biotechnology and Medicine is how the interplay between the genome and the physical environment drives pattern formation and morphogenesis. As well as experimental observations, the transformation of the genetic information into a spatial-temporal expression pattern is studied by mathematical models together with relevant methods for the analysis of real data, such as geometric statistics and inverse problems. It is our goal to bring together developmental biologists and mathematicians in order to promote a multi-disciplinary approach, by utilizing mathematical modelling, analysis, numerical simulation and visualization in order to validate models based on real experimental data. Major challenges exist in spanning quantitatively the enormous scale gaps that link observational molecular genetics to cell dynamics, cell dynamics to organ function and organ function to organism behaviour. From such perspectives, phyllotaxis is a good model system to investigate. Modelling and simulation related to in vivo and in vitro experiments will have many implications for research in biology and medicine. Final scope of the research would be the development of significant mathematical models suitable for understanding the basic biological issues that may lead to diagnosis, prevention and cure of malfunctioning.

Speakers & Talks

Robert Anderssen, CSIRO Mathematical and Information Sciences, Australia
Talk: The “Genetics of Geometry” as an Inverse Problem
Tony Bracken, The University of Queensland, Australia
Talk: Pattern formation through competitive exclusion
Daniela Candia Carnevali, University of Milan, Italy
Talk: Functional morphology, the two intrinsic facets of the biological systems: challenging problems
Vincenzo Capasso, University of Milan, Italy
Talk: Stochastic geometric models and related statistical issues in tumour induced angiogenesis
Mark Chaplain, University of Dundee, UK
Talk: Dynamic heterogeneous Spatio-temporal pattern formation in a model of cancer cell invasion
Qiang Du, Penn State University, USA
Talk: Morphology of single and multicomponents lipid vesicles
Lisa Fauci, Tulane University, USA
Talk: Dynamics of ciliary beating
Andrew Fleming, University of Sheffield, UK
Talk: The integration of cell division and morphogenesis: a combined computational and experimental approach
Avner Friedman, The Ohio State University, USA
Talk: Multiscale models of tumors
Jim Haseloff, University of Cambridge, UK
Talk: Tools for Engineering of Morphogenesis in Plant Systems
Thomas Holstein, University of Heidelberg, Germany
Talk: Wnt signalling and de novo pattern formation in cnidarians
Martin Hülskamp, University of Cologne, Germany
Talk: Modelling the initiation and positioning of arabidopsis trichomes
Willi Jäger, University of Heidelberg, Germany
Talk: Mathematical Modeling of Reactive Flow, Diffusion and Transport through Biological Membranes and Tissue
Henrik Jönsson, Lund University, Sweden
Talk: Models of pattern formation in the plant shoot

Hsun-Chih Kuo
Talk: Segmentation Approach for Feature Selection on Classifying Proteomic Spectra Data
Ulrich Lüttge, Darmstadt University of Technology, Germany
Talk: Spatiotemporal patterns in leaves during the photosynthetic cycle of crassulacean acid metabolism (CAM) elucidated by a ping-pong between experiment and model-simulation
Philip Maini, University of Oxford, UK
Talk: Pattern formation on growing domains
Daphne Manoussaki, Technical University of Crete & Vanderbilt University, Greece
Talk: The cochlear spiral shape and its relation to hearing
Anna Marciniak, University of Heidelberg
Talk: Mechanisms of pattern formation in multicellular systems: mathematical modelling versus experimental ndings
Peter Markowich, Cambridge University, UK; University of Vienna, Austria
Talk: Reaction-Diffusion (Convection) Equations and Entropies
Hans Meinhardt, Max Planck Institute for Developmental Biology, Germany
Talk: Models of biological pattern formation: from elementary steps to the organization of embryonic axes
Nadya Mozorova, University of Illinois at Chicago, USA
Talk: Mathematical modelling of growth and pattern formation in plants.
Markus Owen, University of Nottingham, UK
Multiscale modelling of vascular tissue growth, blood flow and angiogenesis
Sergiy Pereverzyev jun., RICAM
Talk: Algebraic Modelling of Pattern Formation in Plants
Toshio Sekimura, Chubu University, Japan
Talk: Color Pattern Formation in Butterfly Wing and Fish Skin Surface — Experiments and Models
Jonathan Sherratt, Heriot-Watt University, UK
Talk: Modelling cell adhesion in development and disease
Richard Smith, University of Calgary, Canada
Talk: Transport-based Models of Patterning in Plants
Peter Waterhouse, CSIRO Plant Industry, Australia
Talk: Modelling the Dynamics of Gene Silencing in Plants

3.3 SPECIAL SEMESTER ON STOCHASTICS WITH EMPHASIS ON FINANCE

The Special Semester on Stochastics with Emphasis on Finance held at the RICAM will take place from September until December 2008.

We quote from the following public announcement:

The goal of the Special Semester is to provide a stimulating environment for mathematicians, quantitative economists and, in particular, researchers in the areas of applied probability and analysis, computational methods, and finance to jointly address emerging challenges in the interface between stochastics and finance.

The aim is to focus in particular on the following topics that are at least partly related to research conducted at RICAM itself:

1. Inverse and partial information problems: methodology and applications.
2. Optimization and optimal control.
3. Computational methods with applications in finance, insurance and the life sciences.

4. Stochastic methods in partial differential equations and applications of deterministic and stochastic PDE's.
5. Advanced modeling in finance and insurance.

Leading experts in one or more of the above topics, talented PostDocs and doctoral students will have the opportunity to collaborate at RICAM in an interdisciplinary atmosphere in order to gain new perspectives and to develop novel approaches.

The specific activities planned for the Special Semester are:

- an initial "autumn school" on the various topics of the Semester intended mainly as a tutorial for the benefit of younger participants.
- Thematic workshops for a duration of up to one week.
- Social events.

The Special semester should also allow

- for senior researchers to have the possibility to conduct collaborative research with colleagues on topics related to those of the Special Semester,
- for the younger participants to conduct research with other scientists who are present,
- for all participants to spontaneously organize additional research activities according to their ideas and needs.

Finally, the plan is also to have some practitioners involved in the activities.

Funding is available both for longer and shorter stays at RICAM.

The following scientists have already accepted the invitation:

O. Barndorff-Nielsen, M. Deistler, E. Eberlein, H. Foellmer, J.-P. Fouque, H. Gerber, G. Haller, C. Hipp, B. Jourdain, I. Karatzas, D. Lamberton, B. Oeksendal, H. Pham, O. Pironneau, C. Rogers, H. Schmidli, A. Sulem, N. Touzi, T. Zariphopoulou and we expect various others to join in soon.

Scientific Committe:

- H. Albrecher (RICAM and University of Linz)
- K. Kunisch (RICAM and University of Graz)
- W. Runggaldier (University of Padova, chairman)
- H. Pikkarainen (RICAM)
- W. Schachermayer (RICAM and TU Vienna)

3.4 SPECIAL SEMESTERS – PUBLICATIONS AND OUTCOME

RICAM is now connected to a newly created book series to be published by de Gruyter, Berlin, called the

"Johann Radon Series for Computational and Applied Mathematics".

The editorial board consists of: Hansjörg Albrecher, Heinz W. Engl (Editor-in-Chief), Ronald Hoppe, Karl Kunisch, Ulrich Langer, Harald Niederreiter, and Christian Schmeiser.
In this book series, we will both publish material originating from the special semesters and research monographs in computational and applied mathematics. The following volumes have been accepted:

1 - J. Kraus, U. Langer, Lectures on Computational Methods in Mechanics
2 - G. Regensburger, H. Park, Gröbner Bases in Control Theory and Signal Processing
3 - M. Rosenkranz, D.M. Wang, Gröber Bases in Symbolic Analysis
4 - S. Repin, Lectures on a posteriori estimates for differential equations
5 - J. Kraus, S. Margenov, Robust algebraic multilevel methods and algorithms

The first 3 volumes already appeared.

One further outcome of the Special Semester on Groebner Bases is the Journal of Symbolic Computation, Volume 42, with the special issue on Non-Commutative Groebner Bases and Applications. Guest Editor of this volume was Viktor Levandovskyy who visited the Special Semester at RICAM in 2006.

3.5 SEMINARS, COLLOQUIA, VISITORS

The number of external visitor to the institute, both within the special semesters and independent of them, has grown even more. As in the previous years, the talks have been structured in three groups:

Radon Colloquia:
In these talks, prominent external scientists should present overviews over important fields dedicated also to non-specialists. All RICAM employees are expected to attend these colloquia.

Radon Seminars:
These are a bit more specialized talks, both by our own scientists and by external visitors. They should not strictly focus on a specialized topic but have connections to the work of a least two groups in RICAM and should therefore be attended by all RICAM scientists. One purpose is to initiate internal cooperations, all new PostDocs should give talks in this series.

Group Seminars:
These are specialized talks by internal and external scientists intented mostly for members of the organizing group(s), although, of course, members of other groups are also welcome.

In 2007, the following talks were given in these three groups:

Radon Colloquia

Prof. Wolfgang Runggaldier

University of Padua

Monday, March 26, 17:15, HS 6

Title: Contagious default: Application of methods of Statistical Mechanics in Finance.

Abstract: Firms may default and thus not be able to honor their financial obligations. Default is in general contagious (infectious).

Its study is therefore important for an institution holding a credit portfolio of a large number of defaultable firms.

Interacting particle methods turn out to be a convenient tool to deal with these phenomena. We shall study limit distributions when the number of firms goes to infinity as well as their approximations when the number of firms is finite but large. This allows to explain various phenomena like default clustering and, in general, it allows to view a credit crisis as a microeconomic phenomenon driven by endogenous financial indicators.

(Based on joint work with P. Dai Pra, E. Sartori, M. Tolotti).

Prof. Rolf Jeltsch

ETH Zurich

Friday, March 30, 15:30, HF9901

Title: Essentially Optimal Explicit Runge-Kutta Methods with Application to Hyperbolic-Parabolic Equations

Abstract: Essentially optimal explicit Runge-Kutta methods consider more stages in order to include a particular spectrum in their stability domain and thus reduce step restrictions. This idea, so far used mostly for real line spectra, is generalized to more general spectra in form of a thin region. In this regions the eigenvalues may extend away from the real axis into the imaginary plane. We give a direct characterization of essentially optimal stability polynomials containing a maximal thin region and calculate these polynomials for various cases. Semi-discretizations of hyperbolic-parabolic equations are a relevant application which exhibit a thin region spectrum. As a model, linear scalar advection-diffusion is inverstigated. The second order stabilized Runge-Kutta methods derived from the stability polynomials are applied to advection-diffusion and compressible, viscous fluid dynamics in numerical experiments. Due to the stabilization the time step can be controlled solely from the hyperbolic CFL condition even in the presence of viscous fluxes.

Prof. Lothar Reichel

Department of Mathematics, Kent State University

Thursday, May 24, 17:00, HF136

Title: Multilevel methods for ill-posed problems

Abstract: Ill-posed problems often arise when one is interested in determining the cause of an observed effect, such as when one is interested in restoring an available image that has been contaminated by blur and noise. Image restoration gives rise to large-scale problems, because of the typically large number of pixels that make up an image. We review available iterative methods for the solution of large-scale linear ill-posed problems and focus, in particular, on recently proposed multilevel methods.

Prof. Hoon Hong

North Carolina State University

Thursday, July 5, 10:15, HF136

Title: Connectivity in Semialgebraic Sets

Abstract: A semialgebraic set is a subset of n-dimensional real space defined by a system of polynomial equations and inequalities.

Often a semialgebraic set is made of several connected components.

In this talk, we consider the problem of deciding whether two points in a semialgebraic set are connected, that is, whether the two points lie in a same connected component.

The motivation comes from the observation that many important/non-trivial problems in science and engineering can be often reduced to that of connectivity.

We will briefly review the previous (symbolic, numeric) methods and then informally describe a hybrid method based on gradient fields, which seems to be more efficient than the previous methods in practice.

Prof. Ivan Graham

University of Bath

Monday, November 12, 16:30, HF9901

Title: Robust boundary integral methods in high frequency acoustic scattering

Abstract: In this talk we give a survey of robust numerical methods for computing the scattering of a high-frequency incident plane wave uI(x) = exp(ikx ·bd) by a bounded obstacle _ Rm with boundary □□ (where bd is a unit vector and m = 2 or 3). The scattered wave uS satisfies the Helmholtz equation:

_uS + k2uS = 0 in 0 = Rd\ , subject to suitable boundary and far field conditions. In many practical applications (where the physical wavelength is small compared to the diameter of the scatterer), the wave number k is very large and the solution is highly oscillatory. Conventional (piecewise polynomial based) numerical methods have complexity which grows polynomially in k and thus become unusable for large k.

In recent years there has been considerable interest in design of numerical methods which build in information about the asymptotic behaviour of these problems as k ! 1. Some of these methods are (almost) uniformly accurate as the wave number k increases, and can be realised in a computational time which is robust in k also. This talk will give a survey of methods of this type and their analysis, including recent results of the speaker together with V. Dominguez and V. Smyshlyaev as well as work by others active in this field. The methods discussed will be based on boundary integral reformulations of the

Helmholtz equation and the key components of the algorithm design and analysis which

will be discussed are:

(i) Estimates for the continuity and coercivity of the boundary integral operators explicitly in terms of k.

(ii) A proper description of the asymptotic behaviour of the solution in a format suitable for numerical analysis, by further development of the classical asymptotics results for this problem.

(iii) Design of suitable ansatz spaces for use in the Galerkin method and the analysis of their consistency error.

(iv) Construction of quadrature methods for the highly oscillatory Galerkin integrals. In the talk we will describe recent results in this field and some remaining open problems.

Prof. Ralf Kornhuber

Freie Universität Berlin

Wednesday, Dec. 12, 16:45, HS 9

Title: First steps towards the human gait.

Abstract: A precise prediction of loads and forces within human joints would support surgical decisions and thus increase the overall success of surgery procedures. However, in vivo measurements are hardly possible and credible numerical simulation is demanding task. In this talk, we consider 3D finite element

models of the human knee and particularly concentrate on efficient and reliable multigrid solvers for the arising two body contact problems, heterogeneous domain decomposition methods for the coupling/decoupling of bones and ligaments and contact-stabilized time discretizations.

Radon Seminars

Prof. Josef Schicho

RICAM

Monday, March 19, 15:00, HF136

Title: Blow 'Em Up

Abstract: We guarantee that no human beings and no animals will be harmed in any way by this talk. Moreover, the talk will contain no instigations whatsoever to cause any damages on any public or private property.

Rather, it means to be an invitation to work on a problem related to singularities of algebraic varieties.

Dr. Ronny Ramlau, Dr. James Lu and Dr. Philip Kügler
RICAM
Thursday, March 29, 18:15, HF9901

Title: Regularization of Inverse Problems using sparsity constraints – Analysis and Applications

Abstract: In this talk we consider the regularization of nonlinear operator equations $F(x) = y$. Assuming that the solution of the equation has a sparse expansion with respect to a preassigned frame or basis, we want to develop methods that also enforce a sparse reconstruction. This is usually not the case if e.g. Tikhonov regularization with a quadratic Hilbert space penalty term is used. Instead, we propose the use of a weighted ℓp norm, which allows for $p < 2$ sparse reconstructions. For $1 \leq p < 2$ we will propose iterative minimization strategies for the minimization of the Tikhonov functional, give regularization results and present some examples from image processing. Unfortunately, the choice $p = 1$ does not always yield the sparsest solution, not even in the linear case. Hence, one might think of using an lp-penalty term with $p < 1$ in spite of the arising disadvantages, e.g., loss of norm properties. We demonstrate this approach by means of a numerical study of the chlorine dioxide/chlorite - iodide reaction mechanism. Given real experimental data we try to explain them by as few as possible reactions taking place while still guaranteeing chemical soundness of the result. Sparsity-based techniques are also being applied to address problems of systems biology, where a methodology has been developed for performing inverse dynamical analysis within the experiment-model-experiment loop as a way to guide the process of initial model-building and the proposal of new experiments.
The importance of the considered applications and the promising results achieved by the use of the sparse structure of the solutions justify further intensive research efforts in this field.

Dr. Arnd Rösch, Svetlana Cherednichenko and Nataliya Metla

RICAM

Thursday, March 29, 19:00, HF9901

Title: Approximation and regularization of optimization problems governed by partial differential equations

Abstract: We discuss optimization problems governed by partial differential equations with pointwise inequality constraints.
Error estimates for discretized problems for different types of optimal control problems are presented. We propose a Lavrentiev type regularization for state constrained problems.
Moreover, a suitable tuning of regularization parameter and mesh size is presented. In the last part we investigate stability properties of nonlinear problems. Based on this, the local quadratic convergence of an SQP-algorithm is shown for a general class of nonlinear problems.

Group Seminars

GROUP: Computational Methods for Direct Field Problems

Dr. Stefan Gerhold

TU Wien

Thursday, January 11, 15:00, HF136

Title: Special Functions: Applications of Computer Algebra in Stochastics

Abstract: For modeling and simulating micro-electro-mechanical systems (MEMS), multi physics aspects must be taken into consideration. From the numerical point of view additional problems arise since frequently we are confronted with multi-scale problems. Therefore advanced numerical methods have to be applied. At the same time the coupled mechanical and electrical behavior have to be taken into account. This can be achieved by dividing the model into an electrical part and a mechanical part.
The interaction between them can conveniently be realized by using a staggered simulation approach. An interesting example of MEMS is the so-called electrostatic force microscope (EFM) which can be used for scanning samples with nearly atomic resolution.

For developing a model of the EFM different effects have to be considered. For example long distance interaction, charge distribution and non-linearity of the material properties, singularity etc. In order to take into consideration these effects the simulation region is divided into three regions. As high values of the electric field will occur at the pick of the tip, a special numerical method is needed to calculate these electric field more effectively.
For this reason an augmented FEM method will be applied to region near the tip. Since charge distribution and nonlinearities of the dielectric properties may have to be considerd, a versatile numerical method such as finite element method (FEM) should be applied to the next region . As boundary element method (BEM) works well when the boundary is infinite or semi-infinite, the large distance interaction between the tip and the cantilever can be conveniently treated by using BEM in the rest of the region.
Later all these three numerical methods will be coupled with each other.

In this talk a coupled simulation will be presented considering charge distribution on the measur- ing object. Since the scanning process of EFM is dynamic, one has to deal with a moving sample and moving boundaries. As a result the mesh has to be updated at each time step. The approach presented here for mesh updating is based on an arbitrary Lagrangian Eulerian (ALE) algorithm.

GROUP: Inverse Problems

Dr. Eva Sincich

RICAM

Wednesday, January 31, 14:00, HF 136

Title: Some inverse problems on the determination of boundary terms and inverse scattering.

Abstract: In this talk I will present some results concerning the stability and the reconstruction for an inverse corrosion problem and for a scattering problem. I will also introduce some new issues arising in the determination of boundary terms and in inverse scattering.

GROUP: Computational Methods for Direct Field Problems

DI René Simon

SFB 013

Tuesday, January 23, 15:30, T1010

Title: On Schwarz-type smoothers for saddle point problems with applications to PDE-constrained optimization problems

Abstract: In this talk we consider additive (and multiplicative) Schwarz-type iteration methods for saddle point problems as smoothers in a multigrid method. Each iteration step requires the solution of several small local saddle point problems. In a previous work (by Joachim Schöberl and Walter Zulehner) the general construction of such patch smoothers for mixed problems were discussed. It was shown that, under suitable conditions, the additive Schwarz-type iteration fulfills the so-called smoothing property, an important part of a multigrid convergence proof, and the theory was applied to the Stokes problem.
Here we consider a certain class of optimization problems from optimal control. A natural property of the corresponding Karush-Kuhn-Tucker (KKT) system, a 2-by-2 block system which characterizes the solution of the optimization problems, is the positivity of the (1,1) block only on the kernel of the (2,1) block. Therefore, a straight forward application of this construction to KKT systems for elliptic optimal control problems fails. We extend the results for the Stokes problem to PDE-constrained optimization problems and present a patch smoother, which allows a rigorous convergence analysis of the corresponding multigrid method.

GROUP: Optimization and Optimal Control

Dr. Dirk Lorenz

Universität Bremen

Tuesday, February 27, 10:30, HF136

Title: On Generalized Gradient Methods for Non-differentiable Functionals - Application to Tikhonov Functionals with Sparsity Constraints

Abstract: In this talk we invesitgate generalized gradient methods, namely generalizations of the conditional gradient method and the gradient projection method. The motivation for this generalizations comes from Tikhonov functionals with sparsity constraints which are non-differentiable and - for non-linear operators - non-convex.
We show how the generalized gradient methods can be applied to such problems and that they reproduce known algorithms in special cases.

GROUP: Financial Mathematics

Prof. Nicole Bäuerle

University of Karlsruhe

Tuesday March 6, 16:00, HF136

Title: Dependence modeling for multivariate processes with applications in finance and insurance

Abstract: In the first part of the talk we discuss different methods for constructing multivariate counting processes and investigate their properties. As interpretation of these counting processes we have claim arrivals of different business lines of an insurance company in mind. Some asymptotic results of Cramer type for ruin probabilities are also shown.
In the second part of the talk we investigate the class of multivariate Levy processes and characterize dependence properties by means of the Levy measure and the Levy copula. Comparison results for Levy processes are also given. These findings are applied to some financial and actuarial models.

GROUP: Inverse Problems

Dr. Christian Clason

TU München

Tuesday, March 6, 10:30, HF136

Title: A direct method for the numerical time reversal of waves in a heterogeneous medium

Abstract: In this talk we consider the problem of time reversal in a heterogeneous medium as the inverse problem of determining the solution of a wave equation with spatially varying coefficients from lateral Cauchy data. This problem occurs in several applications in the area of medical imaging and non-destructive testing, for example in thermoacoustic tomography.

Using the method of quasi-reversibility, the original ill-posed problem is replaced with a boundary value problem for a fourth order partial differential equation. We find a weak H^2 solution of this problem and show that it is a well-posed elliptic problem. Error estimates and convergence of the approximation follow from exact observability estimates for the wave equation, which are proven using a Carleman estimate. We derive a numerical scheme for the solution of the quasi-reversibility problem by a B-spline Galerkin method, for which we give error estimates. Finally, we present numerical results supporting the robustness of this method for the reconstruction of the wave field from lateral Cauchy data.

GROUP: Financial Mathematics

Oleg Burd

KfW IPEX Bank, Frankfurt

March, 8, 13:00, HF136

Title: "Concentration risk in credit portfolios: identification, measurement and management"

Abstract: The question of dealing with concentration risk in credit portfolios has recently become an issue of emerging concern of the financial community. Both, the second pillar of Basel II as well as financial strength assessments by rating agencies address this subject. Despite the common perception about the sources of concentration risks there are no generally accepted standard methods for its identification and measurement.

In this presentation we describe concentration as a result of an uneven distribution of exposures within credit portfolio either on exposure level (single name concentration) or on sector level (sectoral concentration). We analyze the usage of simple model-free procedures like Herfindahl-Hirschman Index (HHI) for measuring single-name concentration on the basis of results for a sample portfolio. Furthermore, to deal with the issue of sector concentration we introduce more advanced modeling approaches, like the diversification index as developed by Tasche[1] and some other concentration indices. Finally, we show how the findings of the concentration analysis can be used in risk management processes, starting from stress testing to limit management.

GROUP: Financial Mathematics

Dr. Valerie Girardin
Laboratoire de Mathématiques Nicolas Oresme, Université de Caen
Thursday, March 29, 16 :30, HF136

Title: "Entropy and semi-Markov processes"

Abstract: "Entropy and Markov processes are linked since the first version of the asymptotic equirepartition property (AEP) stated by Shannon in 1948 for Markov chains. We define explicitely the entropy rate for semi-Markov processes and extend the AEP or ergodic theorem of information theory to these nonstationary processes.

Among a given collection of functions satisfying constraints, selecting the one with the maximum entropy is equivalent to adding the least of information possible to the considered problem. The definition of an explicit entropy rate for processes allows one to extend the maximum entropy method to their case. When only observations are available, the problem of estimating the entropy rate naturally arises. We study different problems for Markov and semi-Markov processes, illustrated in reliability, queueing theory and seismology."

GROUP: Financial Mathematics

Prof. Ralf Wunderlich
Westsächsiche Hochschule Zwickau
Tuesday, March 13, 13:00, HF136

Title: Optimal Portfolio Policies Under Bounded Expected Loss and Partial Information

Abstract: We address the dynamic portfolio optimization problem where the expected utility from terminal wealth has to be maximized. The special features of this paper are an additional constraint on the portfolio strategy modeling bounded shortfall risks and a model of the financial market with partial information.

The shortfall risk is measured by an expected loss criterion resulting from averaging the magnitude of the losses. Stock prices are assumed to satisfy a stochastic differential equation with a drift parameter modeled as an unobservable continuous-time, finite state Markov chain (HMM).

We obtain quite explicit representations for the form of the optimal terminal wealth and the trading strategies which we compute using Monte Carlo methods. Numerical examples illustrate the analytical results.

GROUP: Computational Methods for Direct Field Problems

Nagaiah Chamakuri
Otto-von-Guericke University Magdeburg

Tuesday, April 17, 15:30, HF136

Title: Adaptive Numerical Simulation of Reaction-Diffusion Systems

Abstract: In my talk I will present the adaptive numerical simulation of intracellular calcium dynamics. Calcium is an important second messenger in cell communication. The dynamics of intracellular calcium is determined by the liberation and uptake by cellular stores as well as reactions with buffers. We develop models and numerical tools to study the liberation of calcium from the endoplasmic reticulum (ER). This process is characterized by the existence of multiple length scales. The modeling of diffusion, binding and membrane transport of calcium ions in cells leads to a system of reaction-diffusion equations. We used piecewise linear finite elements for the spatial discretization and time discretization by a linearly implicit Runge-Kutta scheme. In our description the dynamics of IP3-controlled channels remains discrete and stochastic. The strongly localized temporal behavior due to the on-off behavior of channels as well as their spatial localization is treated by an adaptive numerical method. We present sequential and parallelized numerical results.

GROUP: Analysis of Partial Differential Equations

Dr. Fabio S. Priuli

Math. Dept. NTNU, Trondheim, Norway

Wednesday, April 25, 15:30, HF136

Title: Nearly Optimal Feedback Controls

Abstract: In this seminar, I will present few recent results about the existence of feedback controls for a system x' = f (x, u) which are nearly optimal w.r.t. a given cost J.
This problem is known to have no solutions in terms of continuous controls. One has therefore to introduce a suitable class of discontinuous feedback controls U(x) such that the corresponding system of ODEs still has Carathéodory solutions, and to verify that in such a class there exists a control which almost minimize the prescribed cost. I will review a couple of possible approaches and then focus my presentation on patchy controls, a class of piecewise constants control which is known to satisfy good robustness properties. The main result, recently proved in a joint work with Alberto Bressan, is the construction of a nearly optimal patchy feedback for a general cost J as above.

GROUP: Computational Methods for Direct Field Problems

Chokri Chniti

INRIA

Wednesday, June 13, 15:30, HF136

Title: Improved interface condition for 2D Domain Decomposition with corner"

Abstract: We propose a domain decomposition method for 2-dimensional elliptic problems for which either the geometry or the domain decomposition presents corner singularities.
Starting from the method used for regular interfaces, we derive a local improvement by matching the singularities, which are the first terms of the asymptotic expansion around the corner, provided by Kondratiev's theory. Next, we compute the coefficients of the interface boundary conditions that minimize the number of iterations of the domain decomposition algorithm. This theoretical approach is tested numerically.

GROUP: Financial Mathematics
Prof. Christian Hipp
University of Karlsruhe
Friday, May 11, 14:00, HF136

Title: "Ruin probabilities: the right risk measure for insurers"

Abstract: Ruin probabilities are classical risk measures for insurance which, however, are used scarcely in real world. We emphasize the importance of ruin probabilities, show that they can be computed easily even for complex problems, and demonstrate how they facilitate control problems. In the case of insurance risk management with tax, we compute ruin probabilities as well as total present value of collected tax. With these results we answer the question wether a tax authority should tax an insurer who is close to ruin.

GROUP: Computational Methods for Direct Field Problems

Ivan Georgiev

Bulgarian Academy of Sciences

Wednesday, April 25, 14:00, HF136

Title: Iterative methods for non-conforming finite elements

Abstract: Non-conforming rotated multilinear finite elements were introduced by Rannacher and Turek (R. Rannacher, S. Turek 1992) as a class of simple elements for stable discretization of the Stokes problem. The recent activities in the development of efficient solution methods for non-conforming finite element systems are inspired by their attractive properties as a stable discretization tools for ill-conditioned problems. The model anisotropic elliptic second order boundary value problem is considered. Preconditioned Conjugate Gradient iterative method is used for iterative solution of the resulting linear algebraic system. Two preconditioning algorithms are presented.
Modified Incomplete Cholesky (MIC(0)) preconditioner belongs to the class of incomplete LU factorization methods. Modification of the stiffness matrix is the first step of the algorithm, then MIC(0) factorization is applied. This approach is applied for precondition-ing of separate displacement components of the rotated trilinear FEM elasticity systems.
A real-life benchmark problems are presented. Preconditioners based on various multilevel extensions of two-level finite element methods lead to iterative methods which often have an optimal order computational complexity with respect to the number of degrees of freedom of the system. Such methods were first presented by Axelsson and Vassilevski [O. Axelsson, P. Vassilevski 89&90], and are based
on (recursive) two-level splittings of the finite element space. The key role in the derivation of optimal convergence rate estimates plays the constant γ in the so-called strengthened Cauchy-Bunyakowski-Schwarz (CBS) inequality, associated with the angle between the two subspaces of the splitting. The proposed variants of hierarchical two-level basis are first introduced in a rather general setting. Then, the involved parameters are studied and optimized. The major contribution is the derived estimates of the constant in the strengthened CBS inequality which is shown to allow the efficient multilevel extension of the related two-level preconditioners. Representative numerical tests well illustrate the optimal complexity of the resulting iterative solver.

GROUP: Inverse Problems

Dr. Marcin Janicki

Technical University of Lodz

Tuesday, May 8, 10:30, HF136

Title: „Inverse Thermal Problems in Electronics“

GROUP: Financial Mathematics

Prof. Mihael Perman

University of Ljubljana
Faculty of Mechanical Engineering

Friday, May 25, 11:00, HF136

Title: Ruin probabilities for perturbed risk processes

Abstract: We study a general perturbed risk process with cumulative claims modelled by a subordinator with finite expectation, and the perturbation being a spectrally negative L\'evy process with zero expectation. We derive a Pollaczek-Hinchin type formula for the survival probability of that risk process, and give an interpretation of the formula based on the decomposition of the dual risk process at modified ladder epochs.
In the sequel we consider the following generalization. Let $C_1,C_2,\ldots,C_m$ be independent subordinators with finite expectations and denote their sum by C.
Consider the classical risk process $X(t)=x+ct -C(t)$. Again the ruin probability is given by the Pollaczek-Hinchin formula. If ruin occurs, however, it will be caused by a jump of one of the subordinators whose sum constitutes C. Formulae for the probability that ruin is caused by C_i are derived. These formulae can be extended to perturbed risk processes of the type $X(t)=x+ct-C(t)+Z(t)$ where Z is a L\'evy process with mean 0 and no positive jumps.

GROUP: Mathematical Imaging

Markus Grasmair

University of Innsbruck

Tuesday, May 22, 10:30, HF136

Title: Injectivity and Inversion of Integral Invariants

Abstract: Integral Invariants have been proposed in the fields of shape recognition and classification as robust counterpart to differential invariants. To every point on the boundary of the object of interest a number is assigned, which is defined by integration of a given kernel function over the domain of the object.
One of the central question for their applicability is, whether this assignment is injective, that is, whether a shape is uniquely determined by the corresponding invariant. This is closely related to the problem of reconstructing an object from its invariant. To this end, we make the simplifying assumption that the objects are star-shaped. In this case, the integral invariant of a given object can be considered as function from the sphere to the real numbers, and the integral invariant itself as operator $I : L^n(S^{n-1}) \to L^1(S^{n-1})$.
We focus on two kernel functions, the first being the characteristic function of a cone, the second the characteristic function of a circle. In the first case a necessary and sufficient condition for the injectivity can be derived, the inverse operator, however, turns out to be discontinuous. Numerical reconstructions are given for both the cone and the circle invariant.

GROUP: Financial Mathematics
Prof. Hailiang Yang
Department of Statistics and Actuarial Science, University of Hong Kong
Monday, July 16, 10:30, HF136

Title: Pricing Participating Products Under a Generalized Jump-Diffusion with a Markov-switching Compensator

Abstract: We propose a model for valuing participating life insurance products under a generalized jump-diffusion model with a Markov-switching compensator. We suppose that the jump component is specified by the class of Markov-modulated kernel-biased completely random measures. Our model provides additional flexiblity to incorporate the impact of structural changes in macro-economic conditions and business cycles on the valuation of participating policies by introducing a continuous-time Markov chain. In particular, we assume that the market interest rates, the drift, the volatility and the compensator of the reference asset switch over time according to the state of the Markov chain. We employ the Esscher transform to determine an equivalent martingale measure under the incomplete market setting. We shall conduct simulation experiments to compare the fair values of participating products implied by our model with those obtained from other existing models in the literature and highlight some features that can be obtained from our model.
(This is a joint work with Ken Siu and John Lau).

GROUP: Computational Methods for Direct Field Problems
Prof. Wolfgang Hackbusch
MPI Leipzig
Tuesday, May 15, 15:30, T1010

Title: Evaluation of convolution integrals involving locally refined hp-Functions

Abstract: Let f and g be functions of an hp-element space in R with bounded support.
Here, an hp-element space is characterised by local grid sizes h_l=2^{-l}*h
(l: refinement level). On each subinterval the functions are polynomials of degree <=p (no continuity between the subintervals required). The convolution f*g is the integral of f(y)g(x-y)dy over R. Its (exact) orthogonal L^2 projection into an hp-element space is to be computed.
Wedescribe the algorithm which has the complexity O(p^2*N*log(N)).
Here, N is the number of all subintervals involved in the description of the factors f,g and of the result, p is the maximal polynomial degree.

GROUP: Financial Mathematics
Dr. Andreas Löpker
EURANDOM Eindhoven
Friday, June 15, 11:00, HF136

Title: Transient analysis and asymptotics of the mean of the first hitting time for a TCP window size process

Abstract: The window size in TCP can be modeled as a piecewise deterministic Markov process that increases linearly in time and experiences downward jumps at Poisson times. We present a transient analysis of this process, the main result being a formula for the Laplace transform of the transient moments. Explicit results for the integer and fractional moments are given, as well as an explicit characterization of the speed of convergence to steady-state. We further present results on the first hitting time of the process, including power series for the mean and the Laplace transform and an analysis of the asymptotic behavior. Using these results the asymptotic behavior of the maximum process is investigated.

GROUP: Group: Financial Mathematics
Corina Constantinescu and Stefan Thonhauser
RICAM
Friday, July 6, 11:00 and 11:30, HF136

Talk Constantinescu:
Asymptotic results for the ruin probability in Sparre Andersen models with risky investments
Abstract: Renewal processes are encountered in reliability theory, queuing theory, counter theory or risk theory, where they model the occurrences of events when the inter-occurrence times are independent, identical distributed random variables. In this talk we present a renewal process that has a jump at each renewal time and in between jumps are modeled by a stochastic process, frequently referred to as a jump-diffusion process. In risk theory, this may be used as a model of a non-life insurance business where the renewal times are the claim arrivals, the jumps represent the claim payments and the underlying stochastic process may represent the price of an asset that the insurance company buys using the entire capital at

hand. We introduce an integro-differential equation for functions of this jump-diffusion renewal process in a compact form. Namely, the right-hand side of the equation is a linear operator of the generator of the stochastic process (defined for expected values of functions of the underlying renewal process) and the left hand side is an expected value of the jump process. As an application to the non-life insurance risk model with investments, this approach unifies and also generalizes the integro-differential equations for the probability of ruin that were introduced in previous literature. In this setting, asymptotic results for the ruin probability in Sparre Andersen models with risky investments are derived.

Talk Stefan Thonhauser: Optimal dividend strategies for a risk process under force of interest

Abstract: In the classical Cramer-Lundberg risk model the problem of maximizing the expected cumulated discounted dividends is a widely discussed topic. In the most general case within this framework it is proved (Gerber 1969, Azcue and Muler 2005, Schmidli 2006) that the optimal dividend strategy is of the not very intuitive band strategy type. We discuss this maximization problem in a modified setting including a constant force of interest in the risk model. The value function can be identified in the set of viscosity solutions of the associated HJB equation and the optimal dividend strategy in this risk model with interest can be derived.

This talk could also be of particular interest for members of the "Optimisation and Control" group.

GROUP: Computational Methods for Direct Field Problems
Prof. Martin Schanz
University of Graz
Tuesday, July 10, 15:30, HF136

Title: Time Domain Boundary Element Method: Galerkin Formulation, Coupling, and Perspectives

Abstract: Wave propagation phenomena occur in reality often in semi-infinite regions with areas governed by different physical models. A dam-reservoir system is such a typical example. There, a semi-infinite fluid region is coupled with a dam (e.g., made of concrete) and with the semiinfinite surrounding soil. To simulate such a three-dimensional multi-physical problem several numerical methods have to be coupled and each method itself has to be efficient.

Here, a symmetric Galerkin Boundary Element Method (BEM) based on the Convolution Quadrature Method (CQM) is presented. The essential aspects, particularly the regularization of the hypersingular kernel, are discussed. Some parametric studies are shown including a comparison with the collocation based formulation. In the second part, a mortar type coupling procedure for non-conforming meshes is deduced and verified.

A perspective on future works will close the presentation.

Scientific INTERGROUP activity on imaging
Yayun Zhou
Wednesday, July 11, 13:45, HF136

Title: Cell segmentation using level set method

Abstract: The talk will be about 20 minutes, but there will be ample time to ask questions and think of further extensions of this work and directions for research.

GROUP: Symbolic Computation (could be of special interest to colleagues from Financial Mathematics, espcially those working on equidistribution)
Andriy Bondarenko
University of Kiev
Friday, July 13, 10:00, HF136

Title: “New asymptotic estimates for spherical designs”

GROUP: Computational Methods for Direct Field Problems
Dr. Michael Kuhn
LightTrans GmbH Jena
Friday, July 27, 9:00, HF136

Title: Challenges in Simulation and Design of Optical Systems

Abstract: The simulation of light and its propagation through optical systems is of increasing interest for the development of both, production devices and consumer products. For the design of modern optical components the full electromagnetic information of the light is required. Then the traditional ray tracing methods are no longer sufficient. On the other hand, even state-of-the-art numerical methods cannot solve Maxwell's equations for macroscopic devices (size of several meters) and the corresponding wavelengths

(400..700 nm) using standard PCs.
In this talk, we discuss simulation techniques based on Domain Decomposition ideas and local approximations of the physical model. Some results, including designs of diffractive beam shaping elements, using the optical engineering software "VirtualLab(TM)" (www.lighttrans.com) are presented.

GROUP: Financial Mathematics
Dr. Pavel Gapeev (Weierstrass Institute/LSE)
Thursday, August 23, 16:00, HF136

Title: Optimal stopping problems under incomplete information.

Abstract: In the talk we consider some optimal stopping problems including pricing perpetual American options in models with incomplete information. In order to solve the resulting two-dimensional optimal stopping problems, we formulate equivalent parabolic-type free-boundary problems, where the smooth-fit condition is proved to be satisfied.
By applying the change-of-variable formula with local times on surfaces we verify that the unique solutions of the free-boundary problems turn out to be solutions of the initial optimal stopping problems. It is shown that under some relationships on the parameters of the model some two-dimensional optimal stopping problems admit explicit solutions.

GROUP: Financial Mathematics
Prof. Jose Garrido
Concordia University, Montreal
Monday, August 6, 10:00, HF136

Title: Estimation of the jump size distribution in a Levy risk process

Abstract: Aggregate claims are modeled with a subordinator (non-decreasing Lévy process). Positive jumps larger than a certain threshold represent claims, while more frequent, smaller fluctuations model other, non-insurance sources of uncertainty (other expenses, etc.).
The problem is to estimate the jump measure from a truncated sample path of the aggregate claims process. The assumed sampling scheme is at fixed, discrete time points.
We compare naïve parametric estimators of the subordinator's Lévy measure to an adaptation of the classical non-parametric estimator of Rubin and Tucker for differential processes. This yields also an estimator of the Poisson rate for the number of jumps larger than the threshold.
Illustrative examples such as the gamma, inverse Gaussian or alpha-stable processes are given (joint with Md Sharif Mozumder).

GROUP: Financial Mathematics
Dr. Manuel Morales
Universite de Montreal
Monday, August 6, 10:45, HF136

Title: Constructing Implied Binomial Trees from a Predetermined Stationary Density

Abstract: We introduce a general binomial model for asset prices based on the concept of random maps. The asymptotic stationary distribution for such model is studied using techniques from dynamical systems. In particular, we present a technique to construct a general binomial model with a predetermined stationary distribution. This technique is independent of the chosen distribution making our model potentially useful in financial applications. We briefly explore the suitability of our construction as an implied binomial tree.

GROUP: Financial Mathematics
Dr. Alfred Müller (Heriot-Watt University Edinburgh)
Thursday, August 23, 15:00, HF136

Title: Dependence modelling with Archimedean Copulas and Levy Copulas

Abstract: In recent years there was an increasing interest in better models for dependent risks, and in studying the effect of dependence on the riskiness of portfolios. In this talk it will be demonstrated, how Archimedean Copulas and Levy Copulas can be used in this context. In particular, we derive characterizations of dependence properties and dependence orderings in this context.

GROUP: Optimization and Optimal Control
Dr. Xiliang Lu
RICAM

Wednesday, September 5, 10:00, HF136
Title: A Sequential Regularization Formulation for Navier-Stokes Equations.
Abstract: The Navier-Stokes equations are not a well-posed problem from the view point of constrained dynamical systems. A reformulation to a better posed problem is needed before solving it numerically. A sequential regularization method (SRM) is a reformulation which combines the iterative penalty method with a stabilization method in the context of constrained dynamical systems and has the benefit of both methods. We will discuss this reformulation as well as the connection to the other methods like Uzawa's Algorithm.
GROUP: Financial Mathematics & Symbolic Compuation Prof. Igor Shparlinski Macquerie University Sydney Tuesday, September 18, 10:00, AS50
Title: "Distribution of points on modular hyperbolas"
Abstract: We give a survey of several recent results and pose several open problems about the distribution and some geometric properties of points (x,y) on modular hyperbolas $xy \equiv a \pmod m$. We also outline a very diverse range of applications of such results and discuss multivariate generalisations.
GROUP: Financial Mathematics & Inverse Problems Prof. Wolfgang Stummer University of Erlangen-Nuernberg Monday, October 8, 11:00, HF136
Title: Bregman distances and generalized entropies for financial decision making and statistical censoring
Abstract: We first discuss some connections between Bregman distances and phi-divergences. Special attention is drawn on generalizations of relative entropy (cross entropy, Kullback-Leibler information measure, Tsallis measure, Cressie-Read measure, power divergence). We demonstrate their usage for (1) Bayesian decision making under financial diffusion processes which generalize those in the Black-Scholes context, (2) random right censoring (a concept which is e.g. used in medical statistics). This talk may also be of particular interest for the Inverse Problems Group.
GROUP: Symbolic Computation Dominique Wagner University of Vienna Monday, November 12, 14:00, HF136
Title: Resolution of Quings
GROUP: Symbolic Computation Georg Regensburger RICAM Tuesday, November 13,. 10:00, HF136
Title: Algebraic Inequalities
GROUP: Symbolic Computation Tobias Beck RICAM Tuesday, November 13, 10:40, HF136
Title: Algorithmic Aspects of a Theorem of Jung/Abhyankar - Continuation
GROUP: Financial Mathematics – together with the Institute for Financial Mathematics, University of Linz Mary Flahive Department of Mathematics, Oregon State University Tuesday, November 20, 14:00, T212
Title: Divided Cells: The continued fractions for inhomogeneous problems
Abstract: The divided cell algorithm was introduced by Delone in 1947 to calculate the inhomogeneous

minima of binary quadratic forms. It was developed further by E. S. Barnes and H. P. F. Swinnerton-Dyer in the 1950s. Later, Jane Pitman realized important connections between this algorithm and the continued fractions used in homogeneous approximation. In ongoing collaboration with Dick Bumby, we show how modern advances in both the homogeneous theory and symbolic computation can be used to modify the divided cell algorithm in ways that make it more useful for obtaining information on inhomogeneous problems.

GROUP: Financial Mathematics
Dr. Manuel Guerra
University of Lisbon
Wednesday, November 21, 11:00, HF136

Title: Control theory from the geometric point of view

Abstract: In recent decades, a large set of results in nonlinear control theory where obtained using ideas and mathematical tools from differential geometry. Our aim is to present a brief overview of some basic geometric tools in use by the control theory community. We start by showing how Lie brackets of vector fields arise naturally in the study of nonlinear control systems. This leads directly to the notion of Lie algebra generated by a system. Approximation of integral trajectories of the Lie algebra by trajectories of the system are discussed. Important classical results in this direction are the "orbit theorem" and the Chow-Rashevskii condition for reachability of a control system. In a second part of the talk we introduce flows as families of diffeomorphisms and discuss actions of diffeomorphisms on vector fields. These ideas are used to introduce the so called "variation of constants" and "reduction" formulas of chronological calculus. We illustrate the use of these methods in the study of existence and structure of generalized minimizers for noncoercive optimal control problems.
This talk should also be of interest to other RICAM groups, in particular "Optimisation and Control".

GROUP: Financial Mathematics
Dr. Jean-Francois Renaud
RICAM
Thursday, November 29, 11:00, HF136

Title: Spectrally negative Lévy risk processes with tax and dividends

Abstract: In this talk, we show how fluctuation identities for Lévy processes with no positive jumps can yield interesting results in Lévy insurance risk models with dividends and with taxation. For example, we will compute the distribution of the present value of dividend payments in a model with dividends, and we will
study the ruin probability and the discounted total amount of tax payments in a model with tax. We will also discuss some relations between these two models.

GROUP: Financial Mathematics
Ronnie Loeffen
University of Bath
Tuesday, December 18, 11:30, HF136

Title: On optimality of the barrier strategy in de Finetti's dividend problem for spectrally negative Levy processes

Abstract: The classical optimal dividends control problem introduced by de Finetti has been extensively studied in the Cramer-Lundberg (C-L) risk model. Recently Avram, Palmowski & Pistorius considered the case were the risk process is modelled by a general spectrally negative Levy process. Up till now, an explicit solution to this control problem has only been found in two concrete examples: the C-L model with exponentially distributed claims and the case where the risk process is modelled by a Brownian motion with drift. In both cases the optimal strategy is formed by a barrier strategy. In this talk, we show that if an easy-to-check analytical condition on the Levy measure is satisfied, then the optimal strategy is always of the barrier type. In the analysis the so-called scale functions of spectrally negative Levy processes play a central role.

3.6 CONFERENCES CO-ORGANIZED BY RICAM IN 2007

- RICAM – IMCC – Seminar on Model Reduction, January 29, 2007, RICAM, Linz
- International Workshop on Image Analysis in the Life Sciences, Theory and Applications, Linz, 28 February - 2 March 2007
- Workshop on "Optimization Methods, Approximation and Adaptivity for Optimization Problems with Partial Differential Equations", Linz, March 5 - 9, 2007
- Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, Linz, May 30 - 31, 2007
- MEGA 2007 - Effective Methods in Algebraic Geometry, Strobl, Austria, June 25th - 29th
- 5. Soellerhaus Workshop on Fast Boundary Element Methods in Industrial Applications, October 5-8, Soellerhaus (Kleinwalsertal)
- The Dolomites Research week on Approximation 2007, September 3- 7, 2007, Alba di Canzei, Trento, Italy

3.7 RADON ICIAM GRANTS

We announced 10 grants for junior scientists form the former communist countries in Central and Eastern Europe to visit RICAM for 2 weeks immediately preceding ICIAM07 and then visit that conference in Zürich, travel and local expenses both in Linz and Zürich paid by RICAM. The selection was done by the group leaders based on detailed applications, a prerequisite was an accepted talk at ICIAM. The purpose of this was threefold:

- first, we wanted to contribute to the development of applied mathematics in these countries
- secondly, we wanted to help increase the attendance at ICIAM from these countries
- thirdly, we also wanted to get in touch with promising junior scientists from these coutries with a perspective of establishing scientific cooperations and possibly also offering positions to some of them in the future.

The following persons received these grants:

- Bondarenko Andriy - Kiev National University, Ukraine
- Dashko Olga - S.P.Timoshenko Institute of Mechanics, NASU, Kiev, Ukraine
- Dumitriu Dan - Institute of Solid Mechanics, Bucharest, Romania
- Karabash Illya M. - Institute of Applied Mathematics and Mechanics, Donetsk, Ukraine
- Lazar Martin – University of Zagreb, Croatia
- Lebedeva Evgeniya - Institute of Mathematics, NANU Kiev, Ukraine
- Pop Petrica - North University of Baia Mare, Romania
- Pricop Mihaela - University of Bucharest, Romania
- Qamar Shamsul - Otto-von-Guericke-Universität, Magdeburg, Germany
- Sharapova Svetlana - Moscow State University, Russia
- Tamberg Gert - Department of Mathematics, Tallinn University of Technology, Estonia

In Linz, each of them was assigned a scientific advisor and gave also a talk about his/her work.

Time schedule

1) Opening meeting on Monday, July, 2, consisting the introduction of grant winners to their advisers and vice versa, presentation of RICAM-video, and business lunch where winners and their advisers started to make individual plans.

2) Four seminars for ad-hoc presentations were organized because some of grant winners wanted to present their recent results which were not included in their talks at ICIAM.
The following talks were given in the Inverse Problems Group:

- "Optimization procedure for parameter identification in inelastic material indentation testing" by Dan Dumitriu
- "Sampling operators defined by Rogosinski, Hann and Blackman windows" by Gert Tamberg.
- "Non-standard form of the finite-section approximation for ill-posed operator equations on the half-line" by Evgeniya Lebedeva.

Moreover, the talk

- "New asymptotic estimates for spherical designs" by Andriy Bondarenko was given in the Symbolic Computation Group.

3) On Monday, July 9, all grant recipients and their advisers took part in the "Workshop of RICAM-ICIAM grants winners", where the recipients presented the talks which they intended to present at ICIAM-2007 in Zürich.

All grant recipients were asked to evaluate the effectiveness of the RICAM-ICIAM grants programme giving anonymous answers to the questionnaire "RICAM-ICIAM Grants-2007"; 10 of them estimated their stay at RICAM as very useful, and one – as moderately useful.

We quote from an Email by one of the participants:

"Dear Professor Heinz Engl,

I would like to thank you and Johann Radon Institute for Computational and Applied Mathematics for the Radon-ICIAM grant.
It was a great pleasure to enjoy the kind hospitality of RICAM and to live during two weeks in its creative scientific atmosphere.

Meetings with my adviser, Massimo Fonte, were extremely interesting and have introduced me into a new area of nonlinear PDE problems. I hope that my expertise in Spectral Theory was helpful for him as well.

I wish to express my thanks for an opportunity to participate in ICIAM. It is difficult to describe how much the participation in such a great meeting gives for a young mathematician."

4. THE SCIENTIFIC ACHIEVEMENTS AND PLANS OF THE INSTITUTE

4.1 GROUP "COMPUTATIONAL METHODS FOR DIRECT FIELD PROBLEMS"

Group Leader:
O.Univ.-Prof. Dipl.-Ing. Dr. Ulrich Langer

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Chokri Chniti (employed since September 1, 2007)
Dr. Dylan Copeland (employed until May 31, 2007)
Dr. Marco Discacciati (employed until May 31, 2007)
Dr. Johannes Kraus
Dipl.-Ing. David Pusch (employed until June 30, 2007)
Dr. Satyendra Tomar

Researchers funded via FWF:
Dipl.-Ing. Erwin Karer (employed since September 1, 2007)

Introduction by Group Leader Prof. Ulrich Langer

The "Computational Mathematics Group" (CMG) has focused on the development, analysis and implementation of novel fast computational methods for Partial Differential Equations (PDEs) or systems of PDEs arising in different fields of applications such as solid and fluid mechanics, electromagnetics, and magnetohydro-dynamics.

The first group of methods belongs to Domain Decomposition (DD) methods which can be used for constructing highly efficient parallel solvers for large scale systems of finite element equations as well as for coupling physically different fields and different discretization techniques. We refer to the individual report by M. Discacciati who studied coupled field problems arising in MHD and in CFD, and to C. Chniti who entered the group on 1st of September 2007. Dr. Chokri Chniti is working on special domain decomposition techniques resulting in efficient and, at the same time, robust (e.g. with respect to coefficient jumps in the PDE) solution methods.

The second group of solvers, developed by J. Kraus, S. Tomar and D. Pusch, belongs to geometric and algebraic multilevel methods. Algebraic multigrid and multilevel methods are very important as black-box solvers for practical applications because they do not require any hierarchical discretization structure. J. Kraus and S. Margenov are writing a monograph on robust algebraic multilevel methods and algorithms that will appear in the Radon Series for Computational and Applied Mathematics, which is published by Walter de Gruyter GmbH & KG. J. Kraus started the research project *"Algebraic Multigrid and Multilevel Methods for Vector Field Problems"* granted by the FWF under the **No. P19170-N18** for 3 years. Dipl.-Ing. Erwin Karer entered the project in September as PhD student supported by the FWF. In addition to this, J. Kraus plans to submit his habilitation thesis to the senate of the JKU by the beginning of the year 2008.

Recent publications of the group leader have also contributed to these two main research fields in 2007. The publications [2,4,10,11] are devoted to Boundary and Finite Element Tearing and Interconnecting techniques, whereas the paper [5] deals with geometric and algebraic multigrid methods for large scale data-sparse boundary element equations. The paper [1] is devoted to primal and dual DD methods for solving so-called interface concentrated finite element equations. In [3] we give an overview over coupled boundary and finite element domain decomposition methods. The publication [8] is a survey paper that is devoted to the numerical solution of coupled magneto-mechanical field problems including real-life applications. In [6,7] we discuss the problems arising in

the development of grid-enabled numerical algorithms in CFD. These results were obtained within the Austrian Grid Project. The results were presented in three invited talks [13,14,15]:

[1] S. Beuchler, T. Eibner, U. Langer: Primal and Dual Interface Concentrated Iterative Substructuring Methods, Johann Radon Institute for Computational and Applied Mathematics, RICAM-Report Nr.~2007-7, Linz 2007, and submitted.

[2] U. Langer, G. Of, O. Steinbach, W. Zulehner: Inexact Data-Sparse Boundary Element Tearing and Interconnecting Methods. *SIAM Journal on Scientific Computing,* Vol. 29, No. 1, pp. 290-314, 2007.

[3] U. Langer, O. Steinbach: Coupled Finite and Boundary Element Domain Decomposition Methods, In "Boundary Element Analysis: Mathematical Aspects and Application", ed. by M. Schanz and O. Steinbach, Lecture Notes in Applied and Computational Mechanics, Volume 29, Springer, Berlin, pp. 29-59, 2007.

[4] U. Langer, C. Pechstein: Coupled FETI/BETI solvers for nonlinear potential problems in (un)bounded domains. In *Proceedings of the SCEE 2006* (ed. by Gabriela CIUPRINA and Daniel IOAN), Mathematics in Industry, Vol. 11, Springer-Verlag, Heidelberg, pp. 371-377, 2007.

[5] U. Langer, D. Pusch: Convergence Analysis of Geometrical Multigrid Methods for Solving Data-Sparse Boundary Element Equations. *Computing and Visualization in Science*, appeared online-first, DOI 10.1007/s00791-007-0067-8.

[6] U. Langer, W. Zulehner, H. Yang, M. Baumgartner: GStokes: A Grid-enabled Solver for the 3D Stokes/Navier-Stokes System on Hybrid Meshes. Proceedings of the *6th International Symposium on Parallel and Distributed Computing (ISPDE 2007)* (ed. by Dieter Kranzlmüller, Wolfgang Schreiner and Jens Volkert), held in Hagenberg, Austria, July 5-8, 2007, CPS, 2007, pp. 377-382.

[7] H. Yang, W. Zulehner, U. Langer, M. Baumgartner: A robust PDE solver for the 3D Stokes/Navier-Stokes systems on the grid environment. Proceedings of the 8th IEEE/ACM International Conference on Grid Computing (GRID 2007), September 19-21, 2007, Austin, Texas, USA, pp. 145-152.

[8] M. Schinnerl, M. Kaltenbacher, U. Langer, R. Lerch, J. Schöberl: An Efficient Method for the Numerical Simulation of Magneto-Mechanical Sensors and Actuators. *European Journal of Applied Mathematics*, Vol. 18, pp. 233-271, 2007.

[9] J. Kraus, U. Langer (eds): Lectures on Advanced Computational Methods in Mechanics. Radon Series on Computational and Applied Mathematics, Vol. 1, de Gruyter, Berlin 2007.

[10] U. Langer, M. Discacciati, D.E. Keyes, O.B. Widlund, W. Zulehner (eds): Domain Decomposition Methods in Science and Engineering XVII, Lecture Notes in Computational Science and Engineering, Vol. 60, Springer, Heidelberg 2007.

[11] U. Langer, C. Pechstein: All-Floating Coupled Data-Sparse Boundary and Interface-Concentrated Finite Element Tearing and Interconnecting Methods. SFB F013 "Numerical and Symbolic Scientific Computing", SFB-Report Nr.~2007-30, Linz 2007, and submitted.

[12] U. Langer: Boundary and Finite Element Domain Decomposition Methods. Submitted to the proceedings of the *ENUMATH 2007*.

[13] U. Langer: Domain Decomposition Methods with Boundary and Finite Elements, Invited talk at the BETA 2007, Hannover, Germany, June 2007.

[14] U. Langer: Computational Electromagnetics: From the Simulation to the Optimization, Invited talk at the SCAI Colloquium, Sankt Augustin, Germany, June 11, 2007.

[15] U. Langer: Boundary and Finite Element Domain Decomposition Methods, Plenary talk at the *ENUMATH 2007*, Graz, Austria, September 2007.

The CMG primarily has internal cooperation with the Inverse Problem Group (IPG), the Group "Optimization and Optimal Control" (OOC), the Symbolic Computation Group (SCG), and, of course, with the SFB and the Institute of Computational Mathematics at the Johannes Kepler University Linz.

This internal cooperation as well as the international cooperation is presented in the individual reports by the researchers. In addition to this, the group leader especially cooperates with G. Haase (Graz), O. Steinbach (Graz) and G. Of (Graz) on AMG and DD methods (see publications [2,3]) as well as with T. Eibner (Chemnitz) [1], V.G. Korneev (St. Petersburg), S. Nepomnyaschikh (Novosibirsk) and C. Douglas (Lexington).

The group leader is one of the co-organizers of the workshop *"Fast Boundary Element Methods in Industrial Applications"* held at Hirschegg, October 5-6, 2007, see home page http://www.numerik.math.tu-graz.ac.at/tagungen/FastBEM2007.htm for more information. The 17th International Conference on Domain Decomposition Methods, held at St. Wolfgang / Strobl, Austria, July 3 – 7, 2006, was chaired by the group leader. Together with M. Discacciati, D. Pusch and W. Zulehner the group leader prepared the DD17 proceedings, which was published by Springer Verlag in the series *Lecture Notes in Computational Science and Engineering* (LNCSE) [10]. See DD17 home page http://www.ricam.oeaw.ac.at/dd17 for more information.

The group leader was the main organizer of the **Special RICAM Semester** on *"Computational Mechanics"* held at RICAM in Linz, October 3 – December 16, 2005. The main and most valuable results of the special semester are the joint scientific research activities of the participants, which were initiated during the special semester and which have resulted in joint publications, in improved or new software packages, in joint presentations at conferences, in joint organizations of conferences, workshops, minisymposia etc. Some of the lectures and survey talks were published as first volume in the new Radon Series as a kind of proceedings [9]. At least two monographs were initiated during the Special Semester. Both monographs will appear in the new Radon Series for Computational and Applied Mathematics, which is published by Walter de Gruyter GmbH & KG. The first monograph written by S. Repin is devoted to his lectures on a posteriori estimates for differential equations, which were given during the special semester. The second monograph on *"Robust Algebraic Multilevel Methods and Algorithms*" is prepared by J. Kraus and S. Margenov. Therefore, this follow-up phase has already indicated the long-term impact of this special semester on the scientific community. The homepage of the special semester on *"Computational Mechanics"* http://www.ricam.oeaw.ac.at/sscm/ will be continuously updated with respect to the follow-up phase.
The CMG is a member of the **Austrian Grid Project** supported by the BMBWK under the grant GZ 4003/2-VI/4c/2004. In particular, the work package WP A-3b on "*Distributed Scientific Computing*" that is led by U. Langer, J. Schöberl and W. Zulehner deals with the development and the grid implementation of distributed mesh generators and distributed finite element solvers. See publication [6,7] and the Austrian Grid homepage http://www.austriangrid.at/ for more information. The group leader applied for a sub-project in the Austrian Grid Project 2 which was approved.
In December 2003 we made an agreement on a **Collaborative Research Project** titled "*Robust Scientific Computing Methods and High Performance Algorithms*" between the Johann Radon Institute for Computational and Applied Mathematics (RICAM) of the Austrian Academy of Sciences and the Institute for Parallel Processing (IPP) of the Bulgarian Academy of Sciences. In 2007, J. Kraus and S. Margenov organized a Special Session on "Robust Multilevel and Hierarchical Preconditioning Methods" at the 6th International Conference on "Large-Scale Scientific Computations", Sozopol, Bulgaria, June 5-9, 2007. There are 5 joint publications, see report by J. Kraus below. In addition to this, one monograph by J. Kraus and S. Margenov is in preparation.

Dr. Dylan Copeland (employed until May 31, 2007) moved to the research project FWF-project P19255 "Data-sparse Boundary and Finite Element Domain decomposition Methods" led by Prof. Dr. Ulrich Langer at the Johannes Kepler University Linz in cooperation with Prof. Dr. Olaf Steinbach at the TU Graz. Dr. Marco Discacciati (employed until May 31, 2007) accepted an offer for an assistance professor position at the EPFL (Lausanne, Switzerland). Dipl.-Ing. David Pusch (employed until June 30, 2007) moved to a research position at the ABB AG (Baden-Dättwil, Switzerland).

The **research work of the next years** will be still driven by the development, analysis and implementation of novel fast computational methods for direct field problems arising in different fields of applications. We plan to strengthen the research on **Domain Decomposition and related methods**. Dr. Sven Beuchler (now at the Institute for Computational Mathematics of the JKU), who will join the CMG in September 2008, will work on DD preconditioning for *hp* finite element equations with different applications. The group leader participates in an application for a National Research Network (NFN) on "**Fast Boundary Element Methods in Engineering**". We propose a project on the use of the boundary element technology as unique discretization technique for linear and non-linear boundary value problems in solid mechanics. The boundary element technology allows us to generate new finite element schemes with PDE harmonic basis functions. The development of fast DD solvers is again a hot research topic. In the FWF-project P19255 "Data-sparse Boundary and Finite Element Domain decomposition Methods" that is a joint research project with O. Steinbach (Graz), we develop similar discretization and solver technologies in Electromagnetics. We plan special national and international cooperation on DD technologies with B. Heinrich (Chemnitz), A. Klawonn (Duisburg-Essen), V. Korneev (St. Petersburg), S. Nepomnyaschikh (Novosibirsk), J. Schoeberl (Aachen) and O. Steinbach (Graz). We will continue our research work on **Algebraic Multigrid and Multilevel Methods**, especially, in cooperation with G. Haase (Graz) and with our Bulgarian partners (S. Margenov and I. Georgiev), but also with L. Zikatanov (Pennsylvania State University) who plans to visit RICAM during his sabbatical in the WS 2008/2009. We have organized a special workshop on "Computational Biomechanics" during the Special Semester on "Quantitative Biology analyzed by Mathematical Methods" where we look for new applications of algebraic multiscale methods. S. Tomar proposed and submitted a FWF project on "Isogeometric method for numerical solution of partial differential equations" that has close connection to the research work on solvers. The construction of efficient preconditioners and/or fast solvers for the forward problem is essential for efficient solvers for optimization problems with PDE constraints and for inverse problems, which play an essential role in other RICAM groups.

Dr. Chorki Chniti

Work before joining RICAM

Optimization of the interface conditions:
Domain decomposition methods are now well understood in the case of a regular domain decomposed into regular sub-domains. A significant challenge for the applications is a good comprehension of the singular cases. The choice of the interface operators has a very great influence on the speed of convergence of the algorithm. A new interface boundary condition was proposed. Within the framework of the regular interfaces, this analysis has already been done theoretically and numerically: it relies on a compromise between the optimality and the feasibility of the implementation. This work has been carried out in collaboration with Prof. Dr. Francis Nier and Prof. Dr. Frederic Nataf. The results of this work are three papers.

Acoustic Multiple Scattering:
The aim of this work is to propose a numerical strategy for computing the solution of two-dimensional time-harmonic acoustic multiple scattering problems at high-frequency. The scatterers are assumed to be circular, leading therefore to semi-analytical representation formulae of the scattered field through the solution of a large linear system of equations. Taking advantage of the special block Toeplitz structure of the matrix of the corresponding linear system, we proposed a fast preconditioned iterative method yielding large memory savings. Several numerical experiments for general configurations are presented to show the efficiency of the numerical method. This work has been carried out in collaboration with Prof. Dr. Xavier Antoine and Dr. Karim Ramdani. This work has led to a paper which will appear in the Journal of Computational Physics (2007-2008).

Scientific Achievements of 2007 (September 1 – December 31, 2007)

Since September 2007 we have been working on the so-called skin problem and domain decomposition methods. This work has been carried out in collaboration with the group of "Computational Methods for Direct fields" of Prof. Dr Ulrich Langer (RICAM and University of Linz). We considered an elliptic equation with highly jumping coefficients. At the moment we have studied the Schwarz method as an iterative method: A transmission conditions containing the coefficient of the elliptic equation was proposed, a theoretical study of the optimal parameter near and far from the corner was computed in order to get a fast convergence of the iterative method. Now, we prepare several numerical tests carried out with FreeFem++ software in order to support our theoretical approach numerically.

Scientific Cooperations

Internal
Dr. Johannes Kraus. RICAM, Linz.

External
Prof. Dr. Francis Nier, Department of Mathematics, Rennes 1 university, France.
Prof. Dr. Frederic Nataf, J.L. Lions Laboratory, Paris six university, France.
Prof. Dr. Xavier Antoine, Henri Poincarre Nancy 1 university, France.
Dr. Karim Ramdani, INRIA Lorraine France.

Participation at Conferences, Scientific Visits and Talk

Conferences and Scientific Visits and talk
International conference: Fifth Singular Days CIRM, Luminy, April 23-27, 2007.
International conference: SMAI EVIAN Les bains, March 2005.

Publications 2007

Accepted
[1] X. Antoine, C. Chniti and K. Ramdani, On the Numerical Approximation of High-Frequency Acoustic Multiple Scattering Problems by Circular Cylinders, to appear in Journal of Computational Physics (2007-2008).

Submitted
[2] Improved Schwarz methods for an elliptic problem in a non-convex domain with discontinuous coefficients. Submitted to Numerical Methods for PDE.

Dr. Dylan Copeland

Scientific Achievements of 2007 (January 1 – May 31, 2007)

A mixed method for axisymmetric div-curl systems:
This work was done in collaboration with Prof. J.E. Pasciak and Prof. J. Gopalakrishnan. Div-curl systems generalize static Maxwell equations, and we consider the dimension-reduced systems in the case of symmetry with respect to an axis. In this setting with the necessary weighted spaces, we analyzed finite element discretizations. Also, I have implemented the method in Netgen/NGSolve, a finite element software package developed by Dr. J. Schöberl and colleagues in RICAM. We have written a paper which has been accepted for publication by the journal Mathematics of Computation.

Boundary element based finite element method for Maxwell equations on polyhedral meshes:
I began a research project on the utilization of local boundary element spaces to obtain finite element spaces and discrete operators for three-dimensional electromagnetic scattering problems on general unstructured polyhedral meshes with elements of arbitrary geometry. A theoretical foundation for such a method has been established, and some initial numerical results for both the Helmholtz and Maxwell equations have been obtained. Currently the work is focused on parallel implementation in order to perform large-scale numerical tests. A paper is in preparation.

Scientific Cooperations

Internal
Dipl.-Ing. David Pusch (RICAM)
Dipl.-Ing. Astrid Sinwel (RICAM)

External
Prof. Jay Gopalakrishnan, Department of Mathematics, University of Florida (USA)
Prof. Joseph E. Pasciak, Department of Mathematics, Texas A&M University (USA)
Dr. Guenther Of, Institut für Numerische Mathematik, Graz University of Technology

Publications 2007

[1] D.M. Copeland, J. Gopalakrishnan, and J.E. Pasciak: *A mixed method for axisymmetric div-curl systems.* Accepted by Mathematics of Computation.

Dr. Marco Discacciati

Scientific Achievements 2007 (January 1 – May 31, 2007)

Numerical analysis of magneto-hydrodynamic (MHD) problems:
This work has been carried out in collaboration with the group of `Optimization and Optimal Control' of Prof. K. Kunisch (RICAM and University of Graz), in particular with Dr. R. Griesse (RICAM). The research has focused on the numerical approximation of MHD problems and on the application of optimal control techniques to shape the involved magnetic fields. The numerical analysis of a steady coupled problem has been carried out. Moreover, a C++ code has been implemented in the framework of the code NGSolve provided by the Start-Project led by Prof. J. Schöberl. A research paper has been submitted for publication. The part on optimization has been addressed together with Dr. Griesse and a joint paper is currently in preparation.

Numerical analysis of coupled models for filtration through porous media:
This work has been carried out in collaboration with Prof. A. Quarteroni (Ecole Polytechnique Fédérale de Lausanne and MOX, Milano) and Dr. L. Badea (Romanian Academy of Sciences, Bucharest) and it has focused on the analysis of a coupled Navier-Stokes/Darcy system for modeling filtration processes through porous media. The mathematical analysis of the nonlinear coupled problem has been carried out and domain decomposition techniques have been applied in order to reformulate the problem as a nonlinear equation defined on the hypersurface separating the porous media from the fluid domain. The results obtained have been presented in a research report.

Simulation of nanofiltration processes:
Following an introductory course on numerical methods that I taught at the Institut für Verfahrenstechnik during the winter semester 2006-2007, a joint work has been initiated on the

numerical simulation of rejection phenomena in nanofiltration processes. The research has focused on the application of nonlinear fitting methods to estimate the parameters characterizing the membranes, and on the derivation of suitable models based on the laws of irreversible thermodynamics in order to simulate the concentration drop of aqueous solutions across the membranes. The numerical results are compared with experimental data obtained at the institute.

Scientific Cooperations

Internal
Dr. Roland Griesse (RICAM)
Dr. Joachim Schöberl (START-Project and University of Aachen)

External
Prof. Alfio Quarteroni, Ecole Polytechnique Fédérale de Lausanne (Switzerland) and MOX-Politecnico di Milano (Italy)
Dr. Lori Badea, Romanian Academy of Sciences, Bucharest (Romania)
Dipl.-Ing. Zoltán Kovács, Institut für Verfahrenstechnik, Johannes Kepler Universität, Linz.

Publications 2007

Appeared [A]

1. M. Discacciati, A. Quarteroni and A. Valli. Robin-Robin domain decomposition methods for the Stokes-Darcy coupling. SIAM J. Numer. Anal. 45(3), 1246-1268, 2007.
2. M. Discacciati. Numerical approximation of a steady MHD problem. In Domain Decomposition Methods in Science and Engineering – Proceedings of the 17th International Conference on Domain Decomposition Methods. U. Langer et al, eds. Springer, Berlin, 2007, pages 313-320.

Technical reports

1. L. Badea, M. Discacciati and A. Quarteroni: Mathematical analysis of the Navier-Stokes/Darcy coupling. RICAM, Tech. Report 2007-14, Linz 2007.
2. Z. Kovács, M. Discacciati and W. Samhaber: Modeling of amino acid nanofiltration by irreversible thermodynamics, 2007, submitted.

In preparation

1. M. Discacciati and R. Griesse: Finite element solution of a stationary optimal control problem in magnetohydrodynamics: Stokes case.

During my stay at RICAM I have also collaborated in the editing of the volume “Domain Decomposition Methods in Science and Engineering XVII” published by Springer, which contains the proceedings papers of the 17th International Conference on Domain Decomposition Methods DD17 held in Strobl (Austria) in July 3-7, 2006.

Scientific plans for the cooperation with RICAM after May 31

Despite leaving the institute at the end of May 2007, I plan to continue my scientific cooperation with RICAM.

Erwin Karer advised by Dr. Johannes Kraus

Work before joining RICAM

Double Degree Certificate in Industrial and Applied Mathematics at the Johannes Kepler University Linz (2006) and at the Technical University Eindhoven (2006/2007) passed with distinction. The master's thesis was about "The Design Space Exploration of RF-Circuits". It was written in the framework of an internship at NXP Semiconductors under the supervision of Prof. Wil Schilders. The thesis deals with nonlinear multiobjective optimization problems to determine the optimal parameter settings of certain integrated circuits (e.g. amplifier) to obtain a desired optimal performance.

Scientific Achievements in 2007 (September 1 – December 31, 2007)

I made myself familiar with the basic theory and algorithmic aspects of multigrid and algebraic multigrid methods. In particular I collected and read recent research papers from literature in this field in order to get an overview for my ongoing PhD studies.

Implementation of a new AMG approach in NETGEN/NGSolve: I learned how to apply and to extend the finite element software package NETGEN/NGSolve developed by Prof. Schöberl and the hp-FEM group of RICAM. Later on, I started to implement a new algebraic multigrid (AMG) approach. This method will serve as an efficient preconditioning tool for various types of elliptic boundary-value problems.

In a first step it is planned to compare this particular approach with existing preconditioners. The platform of NETGEN/NGSolve facilitates such comparisons. In a second step it is planned to apply the new technique to linear elasticity problems. A special emphasis will be on (almost) incompressible materials using discontinuous Galerkin discretizations.

Scientific Cooperations

Internal
Dr. Johannes Kraus (RICAM)

Dr. Johannes Kraus

Subjects of Research in 2007

- Algebraic multigrid (AMG) for shape optimization problems.
- Multilevel preconditioning of discontinuous Galerkin (DG) finite element (FE) approximations.
- Construction and analysis of generalized hierarchical bases (HB) and algebraic multilevel iteration (AMLI) methods for Crouzeix-Raviart and Rannacher-Turek FE systems.
- AMG for (linear) elasticity problems.

Publications

Accepted Journal Papers

[1] J. Kraus: Algebraic multigrid based on computational molecules, II: Linear elasticity problems. SIAM J. Sci. Comput., 2007 (in Press).
[2] J. Kraus, S. Margenov and J. Synka: On the multilevel preconditioning of Crouzeix-Raviart elliptic problems. Num. Lin. Alg. Appl., 2007 (in Press).

[3] J. Kraus and S. Tomar: Multilevel preconditioning of elliptic problems discretized by a class of discontinuous Galerkin methods. SIAM J. Sci. Comput., 2007 (in Press).
[4] J. Kraus and S. Tomar: A multilevel method for discontinuous Galerkin approximation of three-dimensional anisotropic elliptic problems. Num. Lin. Alg. Appl., 2007 (in Press), doi:10.1002/nla.544
[5] I. Georgiev, J. Kraus, S. Margenov: Multilevel preconditioning of rotated bilinear non-conforming FEM problems, Computers and Mathematics with Applications (2007), doi:10.1016/j.camwa.2007.11.008

Survey Papers

[6] J. Kraus and S. Margenov: Multilevel methods for anisotropic elliptic problems. In Lectures on Advanced Computational Methods in Mechanics, Radon Series Comp. Appl. Math., vol. 1, J. Kraus and U. Langer eds, pp. 47-88, 2007.

Accepted Proceedings Papers (reviewed)

[7] I. Georgiev, J. Kraus, S. Margenov: Multilevel preconditioning of 2D Rannacher-Turek FE problems; Additive and multiplicative methods. In T. Boyanov, S. Dimova, K. Georgiev, G. Nikolov, eds, Numerical Methods and Applications, pp. 56-64. LNCS 4310, Springer, 2007.
[8] I. Georgiev, J. Kraus, S. Margenov: Multilevel preconditioning of rotated trilinear non-conforming finite element problems. In Proceedings of the 6th Int. Conf. on Large-Scale Scientific Computations, Sozopol, Bulgaria, 2007 (to appear).
[9] J. Kraus and D. Lucas: A fixed-grid finite element algebraic multigrid approach for interface shape optimization governed by 2-dimensional magnetostatics. In Proceedings of the 6th Int. Conf. on Large-Scale Scientific Computations, Sozopol, Bulgaria, 2007 (to appear).
[10] J. Kraus and S. Tomar: A multilevel method for discontinuous Galerkin approximation of three-dimensional elliptic problems. In Domain Decomposition Methods in Science and Engineering XVII, Lecture Notes in Computational Science and Engineering, vol. 60, Langer et al. eds, pp. 155-164, Springer, Heidelberg, 2008.

Submitted Journal Papers

[11] I. Georgiev, J. Kraus, S. Margenov: Multilevel algorithms for Rannacher-Turek finite element approximation of 3D elliptic problems. RICAM-Report Nr. 2007-21, Johann Radon Institute for Computational and Applied Mathematics, Austrian Academy of Sciences, Linz, 2007.
[12] I. Georgiev, J. Kraus, S. Margenov, J. Schicho: Locally optimized MIC(0) preconditioning of Rannacher-Turek FEM systems. RICAM-Report Nr. 2007-32, Johann Radon Institute for Computational and Applied Mathematics, Austrian Academy of Sciences, Linz, 2007.

Talks

1. J. Kraus: Multilevel Preconditioning of Rotated Trilinear Non-Conforming Finite Element Problems. 6th International Conference on "Large-Scale Scientific Computations", Sozopol, Bulgaria, June 5-9, 2007.
2. J. Kraus: A Multilevel Method for Discontinuous Galerkin Finite-Element Equations: 3D Anisotropic Problems. 6th International Congress on Industrial and Applied Mathematics (ICIAM'07), Zürich, Switzerland, July 16-20, 2007.
3. J. Kraus: Multilevel Methods for Nonconforming Finite Element Approximations of Elliptic Problems with Large Jumps in the Coefficients. Miniworkshop on Multiscale Elliptic Solvers, Linz, November 9, 2007.

Scientific Cooperations

Internal

- Prof. Dr. J. Schicho, RICAM, Linz. Topic: Symbolic techniques for optimal M-matrix approximation of (local) finite element stiffness matrices.

- Dr. S. Tomar, RICAM, Linz. Topic: Multilevel preconditioning of DG approximations of 3D anisotropic elliptic problems.

External
- Prof. Dr. S. Margenov, Institute for Parallel Processing (IPP), Bulgarian Academy of Sciences (BAS), Sofia, Bulgaria. Topics: (a) Multilevel methods for non-conforming finite element problems, in particular, for DG formulations. (b) Work on monograph.
- Dr. I. Georgiev, IPP, BAS, Sofia, Bulgaria. Topic: AMLI for non-conforming finite element methods (FEM).
- Prof. Dr. L. Zikatanov, Penn State University, Pennsylvania, USA. Topics: (a) AMG for almost incompressible elasticity. (b) Theory of nonlinear AMLI.

Achievements

- Editor of "Lectures on Advanced Computational Methods in Mechanics", Radon Series Comp. Appl. Math., vol. 1, Walter de Gruyter, Berlin-New York, 2007.
- Co-organizer of the Special Session on "Robust Multilevel and Hierarchical Preconditioning Methods" at the 6th International Conference on "Large-Scale Scientific Computations", Sozopol, Bulgaria, June 5-9, 2007.
- Research Project (No. P19170-N18) on the subject "Algebraic Multigrid and Multilevel Methods for Vector Field Problems" funded by the "Fonds zur Förderung der wissenschaftlichen Forschung (FWF)". With a term of 3 years, this project creates one additional PhD position at RICAM.

David Pusch advised by Prof. Ulrich Langer

Scientific Achievements 2007 (January 1 – June 30, 2007)

Hierarchical Matrices:
Together with U. Bala from the University of Hannover we improved a software code for solving coupled FEM-BEM systems. During his one month stay in Linz, we were able to replace the old FORTRAN code for generating the dense boundary element matrices. Now we are using the adaptive cross approximation for constructing hierarchical matrices, which yield an appropriate approximation of the discrete single layer potential, double layer potential and hypersingular operator. More precisely, we have successfully implemented the C++ software package AHMED, developed by M. Bebendorf. The first tests have showed a huge acceleration concerning the set-up time of the boundary element matrices and the matrix-times-vector multiplications of the iterative solver.
Moreover, we improved the memory management of the code, which provided an additional speed-up of the iteration time. Finally, a simple diagonal preconditioner was applied to reduce the number of iteration. More advanced preconditioners should be tested in future work.

Boundary Element based Finite Element Method:
The assembling of the symmetric approximation of the Steklov-Poincarè operators from our polygonal mesh provides a sparse system matrix. The discretization error of our approach can be estimated by applying Strang's Lemma. Actually, the result can be carried over to norms, which finally reflect an estimation result of G. C. Hsiao and W. L. Wendland. In order to solve the resulting matrix system of equations, we are using the algebraic multigrid package PEBBLES. One can also think of applying geometric multigrid on non-nested meshes. J. H. Bramble and J. E. Pasciak showed that the convergence of multigrid algorithms on a set of non-nested meshes is ensured under certain conditions. We would like to apply this theory on our approach, where the transfer operators between the meshes are given by the representation formula on each domain.

Scientific Cooperations

Internal
Prof. Dr. U. Langer: RICAM & Institute of Computational Mathematics, JKU Linz
Dr. D. Copeland, RICAM, Austrian Academy of Sciences, Linz
Dr. W. Elleithy, Institute of Computational Mathematics, JKU Linz

External
M. Sc. U. Bala, Theoretische Elektrotechnik, University of Hannover

Participation at Conferences, Scientific Visits and Talk

Scientific Visits
D. Pusch: *Data-sparse and sparse preconditioners for boundary element matrices*, ABB Schweiz AG, CH-Baden-Dättwil, January 21 – 22, 2007.

Publications 2007

Appeared
[1] U. Langer, D. Pusch. *Convergence Analysis of Geometrical Multigrid Methods for Solving Data-sparse Boundary Element Equations.* Computing and Visualization in Science, 2007, appeared online-first, DOI 10.1007/s00791-007-0067-8

Dr. Satyendra Tomar

Scientific Achievements 2007

In continuation to our (with Prof. S. Repin and R. Lazarov) previous work on functional a posteriori error estimates for discontinuous Galerkin (DG) approximations of elliptic boundary-value problems we have devised more efficient schemes to deal with difficult problems, e.g. sharp peaks and jump in the PDE coefficients. Further, based on the Helmholtz type decomposition, we are developing new a posteriori error estimates for nonconforming approximation of elliptic problems. Moreover, some work on functional a posteriori error estimates for Nitsche type mortaring on non-matching grids has also been done and it will be completed in due course of time.

Dr. J. Kraus and I are developing optimal order algebraic multilevel iterative (AMLI) methods for a general DG finite element discretization of anisotropic elliptic boundary-value problems. A specific assembling process, similar to the ones proposed in SISC and NLAA articles mentioned below, is being worked upon which would allow to characterize the hierarchical splitting locally.

Scientific Cooperations

Internal
Dr. J. Kraus (RICAM)

External
Prof. J.J.W. van der Vegt (University of Twente, Netherlands)
Prof. R. Lazarov (Texas A&M, College Station, Texas, USA)
Prof. S. Repin (St. Petersburg, Russia)
Prof. R. Stenberg (Helsinki University of Technology, Finland)

Participation in Conferences/Workshops and Scientific Visits

1. 6th International Conference on Large-Scale Scientific Computations, Sozopol, Bulgaria, June 5-9, 2007.
2. 3rd International Workshop on Reliable Methods of Mathematical Modeling, St. Petersburg, Russia, July 24-27, 2007.
3. 7th European Conference on Numerical Mathematics and Advanced Applications, Graz, Austria, September 10-14, 2007.

Scientific Talks/Lectures

1. S.K. Tomar (with J. Kraus): A multilevel method for discontinuous Galerkin approximation of three-dimensional anisotropic elliptic problems, RICAM Group Seminar, Jan 30, 2007.
2. S.K. Tomar (with J. Kraus): A multilevel method for discontinuous Galerkin approximation of three-dimensional anisotropic elliptic problems, 6th LSSC, June 8, 2007.
3. S.K. Tomar (with S. Repin): Guaranteed and computable a posteriori error estimates for discontinuous Galerkin approximations of elliptic problems, 3rd RMMM, July 26, 2007.
4. S.K. Tomar (with S. Repin): Practical aspects of functional a posteriori error estimates for discontinuous Galerkin approximations of elliptic problems, 7th ENUMATH, September 10, 2007.

Publications 2007

Appeared

1. S.K. Tomar and J.J.W. van der Vegt: A Runge-Kutta discontinuous Galerkin method for linear free-surface gravity waves using high order velocity recovery, Computer Methods in Applied Mechanics and Engineering (2007), 196, 1984-1996.
2. J.K. Kraus and S.K. Tomar: Multilevel preconditioning of two-dimensional elliptic problems discretized by a class of discontinuous Galerkin methods. SIAM J. Sci. Comput., in Press.
3. J.K. Kraus and S.K. Tomar: A multilevel method for discontinuous Galerkin approximation of three-dimensional anisotropic elliptic problems. Numer. Linear Algebra Appl., in Press. DOI 10.1002/nla.544.
4. J.K. Kraus and S.K. Tomar: A multilevel method for discontinuous Galerkin approximation of three-dimensional elliptic problems. In Domain Decomposition Methods in Science and Engineering XVII, Lecture Notes in Computational Science and Engineering, Vol. 60, Langer et al. eds. 155-164. Springer, Heidelberg, 2008.

Accepted

1. R. Lazarov, S. Repin and S.K. Tomar: Functional a posteriori error estimates for discontinuous Galerkin approximations of elliptic problems. Numerical Methods for Partial Differential Equations.

Submitted

1. S.K. Tomar and S. Repin: Efficient computable error bounds for discontinuous Galerkin approximations of elliptic problems.
2. S. Repin and S.K. Tomar: Helmholtz type decomposition based functional a posteriori error estimates for nonconforming approximation of elliptic problems.

Project

A project titled “Isogeometric method for numerical solution of partial differential equations” (duration 3 years, total budget 226,180 Euro, support for 2 Ph.D. positions) has been submitted to FWF**.**

4.2 FWF START PROJECT Y192 "HIGH ORDER FINITE ELEMENTS : FAST SOLVERS AND ADAPTIVITY" LED BY PROF. JOACHIM SCHÖBERL

Group Leader:
Prof. Dr. Joachim Schöberl

Researchers funded via ÖAW:
Prof. Dr. Joachim Schöberl (20%)

Researchers funded via FWF – Start Project:
Dipl.-Ing. Almedin Becirovic (until Mar 31, 2007)
Dipl.-Ing. Martin Huber
Dipl.-Ing. Astrid Sinwel
Dipl.-Ing. Dr. Sabine Zaglmayr

Introduction by the START-Project Leader Prof. Joachim Schöberl

The Start project "hp-FEM" is an FWF-funded young researcher project leaded by J.Schöberl, started 2002, joined RICAM in October 2004, succeeded mid-term evaluation in 2005, and is an independent RICAM project since March 2007. It will last till July 2008. The group leader has accepted a professorship at RWTH Aachen University in March 2006.

The aim of the project is to develop algorithms for high order finite element methods and implement them efficiently into the software package Netgen/NgSolve. We focus on electromagnetic and mechanical application classes. The methods range from discretization methods over preconditioning to a posteriori error estimates. We meet software challenges such as object oriented design and parallelization.

Highlights of the work in 2007 are:
High order methods for Maxwell equations. After her PhD thesis in 2006, S. Zaglmayr continued in this area. New results are elements for pyramids fitting into our concept of local exact sequences, fast integration methods for Maxwell equations, and equilibrated residual error estimators.
Mixed methods in elasticity. A. Sinwel continued with the development of our new Hellinger-Reissner mixed method, where the displacement field is approximated by tangential continuous elements, and the stresses are approximated by normal-normal continuous elements. New results are high order shape functions based on the elasticity complex, robust anisotropic estimates, and applications to contact problems with friction.
Acoustic and electromagnetic wave equations. M. Huber started the simulation of electromagnetic wave defraction on periodic structures in 3D. For this, a plane wave discretization in the external homogeneous region is coupled by a discontinuous Galerkin approach to the finite elements in the complicated local domain. Furthermore, A. Sinwel works on hybrid discretization methods for the acoustic wave equation in frequency domain (Helmholtz equation). We could derive a scheme for which local iterative solvers do converge. With this, we could solve 3D problems with 40 wavelengthes in each direction.
Constant free a posteriori error estimates. The work on equilibrated residual error estimators started by Prof. D. Braess and J. Schöberl douring the special RICAM semester on Computational Mechanics was extended by S. Zaglmayr to high order finite elements. The error estimator delivers an absolute upper bound for the error. Experiments (up to polynomial order 20) indicate that the overestimation of the error is robust with respect to the element order. A proof is work in progress.

Recent publications:

1. S. Hein, T. Hohage, W. Koch, J. Schöberl: Acoustic resonances in a high-lift configuration. *J. Fluid Mech*, vol 582, pp 179-202, 2007
2. J. Schöberl and W. Zulehner. Symmetric Indefinite Preconditioners for saddle point problems with applications to PDE-constrained optimization. *SIMAX*, vol 29, pp 752-773, 2007.
3. M. Schinnerl, M. Kaltenbacher, U. Langer, R. Lerch, J. Schöberl: An Efficient Method for the Numerical Simulation of Magneto-Mechanical Sensors and Actuators. *European Journal of Applied Mathematics*, Vol. 18, pp. 233-271, 2007.
4. J. Schöberl: A posteriori error estimates for Maxwell equations. *Math. Comp*. (to appear).
5. J. Schöberl, J. Melenk, C. Pechstein, S. Zaglmayr: Additive Schwarz preconditioning for p-version triangular and tetrahedral finite elements, IMAJNA (available online).
6. D. Braess, J. Schöberl: Equilibrated residual error estimator for Maxwell equations. *Math. Comp.* (to appear).
7. J. Schöberl, R. Stenberg: Multigrid Methods for Stabilized Reissner Mindlin Plate Formulations (submitted)
8. L. Demkowicz, J. Gopalakrishnan, J. Schöberl: Polynomial Extension Operoators. Part I. RICAM-Report 2007-15 (submitted)
9. L. Demkowicz, J. Gopalakrishnan, J. Schöberl: Polynomial Extension Operoators. Part II. RICAM-Report 2007-16 (submitted)
10. J. Schöberl, A. Sinwel: Tangential-displacement and normal-normal-stress continuous mixed finite elements for elasticity (submitted), RICAM-Report 2007-10
11. M. Huber, J. Schöberl, A. Sinwel, S. Zaglmayr: Simulation of diffraction in periodic media with a coupled finite element and plane wave approach (submitted), RICAM-Report 2007-22
12. D. Braess, J. Schöberl, V. Pillwein: Equilibrated Residual Error Estimates are p-Robust (submitted)
13. D. Braess, R.H.W. Hoppe, J. Schöberl: A posteriori estimators for obstacle problems by the hypercircle method (submitted)
14. R.H.W. Hoppe, J. Schöberl: Convergence of Adaptive Edge Element Methods for the 3D Eddy Current Equations (submitted) RICAM report 2007-25

Participation at Conferences, Scientific Visits and Talk

- J. Schöberl: Equilibrated residual error estimator for Maxwell equations, invited talk at Oberwolfach Seminar on Computational Electromagnetics and Acoustics, Feb 5-9, 2007
- J. Schöberl: Netgen/NgSolve – Mesh generator and finite element solver, invited talk at CMA-workshop “Interplay between representation of geometry and numerical solution of PDEs”, Oslo, Feb 15-16, 2007

The Start-project has internal cooperations with the Symbolic Computations Group (SCG) on RICAM and SFB013, the Computational Mathematics Group (CMG), and the Optimization and Optimal Control Group (OOC). Strong external cooperations are D. Braess (Bochum), L. Demkowicz (Austin, TX), J. Gopalakrishnan (Gainsville, FL), T. Hohage (Göttingen), J.M.Melenk (Wien), P. Monk (Newark, DE), R. Stenberg (Helsinki), R. Winther (Oslo)

Martin Huber advised by Prof. Joachim Schöberl

Scientific Achievements 2007

Modeling of 2D-periodic gratings with FEM: In the interest of generalizing my prior work on 1D-periodic gratings, I used Finite Elements in order to describe the optical behavior of a one-dimensional periodic structure (crossed grating) in a three-dimensional space and the implementation of this problem into the software Netgen/NGSolve.

Electromagnetic waves propagating towards a grating are diffracted and transmitted into certain spatial directions. While the calculation of these directions, which depend only on the period of the structure, is easy to perform, the corresponding intensities, depending strongly on the shape, are much more complicated to compute.
Modeling such a grating with FEM, we have to solve the full set of 3D-Maxwell's equations. Due to the periodicity of the system, we are able to use the theorem of Bloch-Floquet, and the computational domain can be reduced to a single unit cell by formulating quasi periodic boundary conditions. In order to take the physics of the problem into account, it is useful to express the far field by plane waves and exponential decaying functions. A critical point is to couple these plane waves with the polynomial basis functions of the FEM domain. The innovation of our approach is to perform this coupling by Nitsche's method.
By using plane waves describing the far field pattern, simulation results can be compared easily with measurements where these similar quantities to these expansion coefficients are measured.

Simulation of Nanowires: In order to verify experimental results, the behaviour of nanowires in an electric field was simulated. Including physical aspects, I modelled these nanowires, which were randomly distributed over the whole domain at the beginning, as dipoles consisting of two different pointcharges. The background field, needed to describe the movement of the particles was calculated with finite elements.

Scientific Cooperations

Internal
Prof. Dr. DI Joachim Schöberl, RICAM Linz / RWTH Aachen
Dr. DI Sabine Zaglmayr, RICAM Linz
DI Astrid Sinwel, RICAM Linz

External
Dr. DI Herbert Egger, Department for Mathematics CCES, RWTH Aachen, Germany
A.Univ.Prof. Dr. W. Heiß, Institute of Semiconductor and Solid State Physics, JKU Linz, Austria
Univ.Doz.Dr. K. Hingerl, Institute of Semiconductor and Solid State Physics, JKU Linz, Austria
Dr. Andreas Rathsfeld, Weierstrass Institute for Applied Analysis, Berlin, Germany

Participation at Conferences, Scientific Visits and Talk

Conferences
- Numerical Analysis Day, Tech.Univ. Vienna, Austria, 26. - 27. 04. 2007
- Waves 2007, University of Reading, UK, 23.07 - 27.07.2007
- FEM Symposium 2007, TU Chemnitz, Germany, 24.09 - 26.09.2007

Scientific Visits
1. Dr. Andreas Rathsfeld, Weierstrass Institute for Applied Analysis, Berlin, Germany, 22. - 26. 01. 2007

2. Prof. Christian Wieners, Department of Mathematics, University of Karlsruhe, Germany, 12. - 14. 02. 2007

Scientific Talks

1. J. Schöberl and M. Huber: *Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach,* Seminar, Weierstrass Institute for Applied Analysis, Berlin, Germany, 24. 01. 2007
2. J. Schöberl and M. Huber: *Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach,* Numerical Analysis Day, Tech.Univ. Vienna, Austria, 27. 04. 2007
3. J. Schöberl and M. Huber: *Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach,* FEM Symposium 2007, Tech.Univ. Chemnitz, Germany, 24. 09. 2007
4. J. Schöberl and M. Huber: *Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach,* Seminar, RWTH Aachen, Department for Mathematics CCES, Germany, 13. 11. 2007

Publications 2007

Appeared:
M.Huber, J. Schöberl, A. Sinwel and S. Zaglmayr: Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach, RICAM Report 2007-22, October 2007

Submitted
M.Huber, J. Schöberl, A. Sinwel and S. Zaglmayr: Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach, (submitted), October 2007

Astrid Sinwel advised by Prof. Joachim Schöberl

Scientific Achievements 2007

Mixed methods for elasticity:
The Hellinger Reissner formulation of elasticity involves the displacements as well as the stress fields as unknowns. We choose the displacement space to be H(curl). In order to obtain a stable mixed system, the stress space has to be chosen such that the divergence of the stress tensor lies in H^{-1}(div). We call this space H(divdiv).
Finite elements for the space H(curl) require a continuous tangential component to be conforming. To get a conforming subspace of H(divdiv), the normal-normal component of the stress tensor needs to be continuous across element interfaces. For the displacement space, we use hierarchical finite elements of variable polynomial order, which were developed within the start project by J. Schöberl and S. Zaglmayr. For the stresses, we construct hierarchical, symmetric, tensor-valued elements satisfying the required normal-normal continuity. Therefore we use a two-step exact sequence for elasticity.
We hybridize the method to obtain a symmetric, positive definite system matrix. Then a simple block-preconditioner can be used for nearly incompressible materials. The method is locking-free for both anisotropic elements and nearly incompressible materials.
Electromagnetics (in collaboration with Prof. Peter Monk):
We consider the mixed formulation of the Helmholtz equation. There we approximate both u and the flux field σ. We use Nitsche's method to hybridize the system. The Lagrange-parameters used can be interpreted as traces of u and σ. To solve the complex symmetric system, we use a Multiplicative-Schwarz preconditoner (forward-backward block Gauss-Seidel preconditioner) for the cg-iteration. We observe good convergence results.

Another approach is the so-called ultra-weak variational formulation, where the unknowns correspond to incoming and outgoing impedance traces on element interfaces. There we use high-order Raviart-Thomas elements to map incoming to outgoing traces. It is also possible to use plane-wave ansatz functions, which are more suitable for large elements. We use both types in the same mesh, to exploit their respective benefits.

Parallelization of Netgen/NgSolve:

The software package provides a very flexible sequential finite element solver. We added the functionality needed for a parallel environment, and an efficient parallel Additive-Schwarz type solver.

Scientific Cooperations

Internal

Prof. Dr. DI Joachim Schöberl, RICAM Linz / RWTH Aachen
Dr. DI Sabine Zaglmayr, RICAM Linz
DI Martin Huber, RICAM Linz
DI Clemens Pechstein, Institute for Computational Mathematics, JKU Linz
DI Marie-Therese Wolfram, RICAM Linz

External

Dr. DI Herbert Egger, Department for Mathematics CCES, RWTH Aachen, Germany
Prof. Peter Monk, Department of Mathematical Sciences, University of Delaware, USA
Prof. Rolf Stenberg, Institute of Mathematics, Helsinki University of Technology, Finland
Prof. Christian Wieners, Department of Mathematics, University of Karlsruhe, Germany

Participation at Conferences, Scientific Visits and Talk

Conferences

1. WONAPDE, University of Concepcion, Concepcion, Chile, 16. - 19. 01. 2007
2. HOFEM, Herrsching am Ammersee, Germany, 17. - 19. 05. 2007
3. FEM Symposium, Chemnitz, Germany, 24. - 26. 09. 2007

Scientific Visits

1. Prof. Christian Wieners, Department of Mathematics, University of Karlsruhe, Germany, 12. - 14. 02. 2007
2. Prof. Peter Monk, Department of Mathematical Sciences, University of Delaware, Newark, USA, 27. 10. - 26. 11. 2007

Scientific Talks

1. J. Schöberl and A. Sinwel: *Tangential-Displacement and Normal-Normal-Stress Continuous Mixed Finite Elements for Elasticity,* WONAPDE, University of Concepcion, Chile, 18. 01. 2007
2. J. Schöberl and A. Sinwel: *Tangential-Displacement and Normal-Normal-Stress Continuous Mixed Finite Elements for Elasticity,* Poems Seminar, INRIA Rocquencourt, Paris, 26. 04. 2007
3. J. Schöberl and A. Sinwel: *Mixed Finite Element Methods for Elasticity,* HOFEM, Herrsching, Germany, Poster Session, 17. - 19. 05. 2007
4. J. Schöberl and A. Sinwel: *Mixed Finite Elements for Elasticity,* Kickoff-Meeting FWF-Project *Data-sparse Boundary and Finite Element Domain Decomposition Methods in Electromagnetics,* Strobl, 16. 06. 2007
5. J. Schöberl and A. Sinwel: *Mixed Finite Elements for Linear Elasticity,* Chemnitz FEM Syposium, Chemnitz, Germany, 24. - 26. 09. 2007
6. J. Schöberl and A. Sinwel: *Mixed Finite Elements for Linear Elasticity,* Applied Math

Seminar, University of Delaware, Newark, USA, 30. 10. 2007

Publications 2007

Appeared:
J. Schöberl, A. Sinwel: Tangential-displacement and normal-normal-stress continuous mixed finite elements for elasticity, RICAM Report, June 2007
M. Huber, J. Schöberl, A. Sinwel, S. Zaglmayr: Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach, RICAM Report, October 2007

Dr. Sabine Zaglmayr

Scientific achievements in 2007
H(curl)- and H(div)-conforming high order finite elements on pyramidal element topologies:
Pyramidal elements are non-standard element topologies, even they occur as far as we want to conformingly match tetrahedral elements to prismatic or hexahedral ones within hybrid meshes. A crucial point is that matching the interface conditions to general elements implies a subset of the shape function to be no longer polynomial inside the elements. In collaboration with Prof. L. Demkowicz, Dr. Zaglmayr started on defining H(curl)-conforming FE-spaces obeying the global exact sequence property. Following the ideas of her dissertation, she moved on to define and implement shape functions with local exact sequence property for H(curl)-conforming high-order discretizations.

A-posteriori error estimators for Maxwell problems:
In collaboration with Prof. J. Schöberl S. Zaglmayr wants to generalize the equilibrated residual error estimators for Maxwell's equations to high-order FE-discretizations:
Here, we succeeded in the first steps: First, we generalized and simplified the equilibration process for scalar-type problems for higher-order FE-schemes. Second, the implementation of the equilibrated error estimator for the Poisson problem was extended to the 3D case and hybrid meshes. This requires broken (discontinuous) H(div)-finite elements for all element topologies. First numerical results on tetrahedral meshes are very satisfying.
Futhermore, we continued/started our work/cooperations on:
Fast Integration Integration methods for H1 and H(curl) problems with Prof. Dr. J. Schöberl
Periodic piezoelectric problems – harmonic admittance, dispersion relations and various non-reflecting boundary conditions (perfectly matched layers) in cooperation with Dr. M. Mayer and Dr. K. Wagner.
Inverse Electromagnetic scattering (in cooperation with C. Schneider, Dr. H. Egger)
The inverse problem of mine searching is solved by the factorization method. In case of nonhomogenous e.g. background media the fundamental solution is not available. Here an adjoint approach is used which can utilize FEM. Since many solutions of the forward problem - the full Maxwell problem including conductivity - are required, an efficient forward solver is crucial. Here, our expertise on efficient solvers for Maxwell problems applies.

Publications

- J. Schöberl, J.M. Melenk, C. Pechstein, S. Zaglmayr: *Additive Schwarz preconditioning for p-Version Triangular and Tetrahedral Finite Elements,* IMA Journal of Numerical Analysis, 2007, (to appear)

- M.Huber, J. Schöberl, A. Sinwel and S. Zaglmayr: *Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach,* RICAM Report 2007-22, October 2007 (appeard as Report, submitted to Journal).
- M. Mayer, S. Zaglmayr, K. Wagner, J. Schöberl: Perfectly Matched Layer Finite Element Simulation of Parasitic Acoustic Wave Radiation in Microacoustic Devices. 2007 IEEE International Ultrasonics Symposium. (to appear).

Scientific Cooperations

Internal
Dr. DI Joachim Schöberl (RICAM and RWTH Aachen)
DI Astrid Sinwel (RICAM)
DI Martin Huber (RICAM)
DI Clemens Pechstein (Institut für Numerische Mathematik, JKU Linz)
Dr. Dylan Copeland (RICAM)

External
Prof. Dr. Leszek Demkowicz, Institute for Computational Engineering and Sciences (ICES), University of Texas at Austin, USA.
Dr. H. Egger, Center for Computational Engineering Sciences (CCES), RWTH Aachen, Germany.
Prof. Dr. C. Wieners, Instiute for Scientific Computing and Mathematical Modelling, University Karlsruhe, Germany.
Dr. M. Mayer, Dr. K. Wagner, Epcos AG, Munich, Germany.
Dipl.-Math. C. Schneider, Universität Mainz, AG Numerik, Germany.

Participation at Conferences, Scientific Visits and Talk

Conferences

1. 3rd Austrian Numerical Analysis Day, TU Wien, Austria, 26.-27. April 2007.
2. HOFEM 2007, Herrsching, Germany, 17.-19.May 2007.
3. 9th US National Congress on Computational Mechanics, USA, 23.-26.7.2007.

Scientific Visits

1. Prof. Dr. J. Schöberl, CCESS, RWTH Aachen, 22.-26.1.2007, 11.-22.06.2007.
2. Prof. Dr. O. Sigmund, DI R. Stainko, Technical University of Denmark, Lungby, 29.-02.07.2007.
3. Prof. Dr. C. Wieners, University Karlsruhe, Germany, 12.-15.02.2007.
4. DI C. Schneider, University Mainz, Germany, 16.-20.4.2007.
5. Dr. T. Kolev, Lawrence Livermore National Lab, Livermore, USA, 30.7.2007.
6. Prof. Dr. L. Demkowicz, Institute of Computational Engineering and Sciences (ICES), University of Texas at Austin, USA.

Scientific Talks

1. S. Zaglmayr (with J. Schöberl): *High Order Finite Element Methods for Electromagnetic Field Computation*, DTU Lungby, Kopenhagen, Denmark,
2. S. Zaglmayr (with J.Schöberl, D. Braess) : *Equilibrated residual a-posteriori error estimators for Poisson and Maxwell's equations*, 3rd Numerical Analysis Day, TU Wien, 26.-27.4.2007.
3. S. Zaglmayr (with J. Schöberl): *High Order Finite Elements for Vector-Valued Function Spaces,* HOFEM Herrsching, München, Germany, 19.5.2007.

4. S. Zaglmayr (with J.Schöberl, D. Braess): *Equilibrated residual a-posteriori error estimators for Poisson and Maxwell's equations,* 9th US National Congress on Computational Mechanics, 24.7.2007.
5. S. Zaglmar (with J.Schöberl): hp-Finite Elements with local exact sequence property: Applied within Robust Preconditioning and the Maxwell EVP, Lawrance Livermore National Lab, Livermore, 30.7.2007.
6. S. Zaglmayr (with J.Schöberl, D. Braess): Equilibrated residua-based a priorii error estimators for Poisson and Maxwell's equations, Chemnitz FEM Symposium, 25.9.2007.
7. S. Zaglmayr (with J.Schöberl): On High Order Finite Element Methods for Maxwell's Equations, Workshop on Fast Boundary Element Methods in Industrial Applications. 6.10.2008.

4.3 GROUP "INVERSE PROBLEMS"

Group Leader:
o.Univ.-Prof. Dipl.-Ing. Dr. Heinz W. Engl

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Jenny Niebsch
Prof. Dr. Sergei Pereverzyev
Dr. Sergiy Pereverzyev
PD Dr. Ronny Ramlau
Dr. Elena Resmerita
PD Dr. Arnd Rösch (left March 31, 2007)

Researchers externally funded:
DI Stephan Anzengruber
Dipl.-Tech. Kattrin Arning
Dr. Hui Cao
MSc Svetlana Cherednichenko (left June 30, 2007)
Dr. Lin He (left December 31, 2007)
Dr. Marcin Janicki
Dr. Esther Klann
DI Klaus Krumbiegel (left June 30, 2007)
Dr. James Lu
Dr. Shuai Lu
Mag. Svetlana Metla
Dr. Stefan Müller
Dr. Hanna Katriina Pikkarainen (left December 31, 2007)
Dr. Eva Sincich
Dr. Mourad Sini
DI Marie-Therese Wolfram
DI Clemens Zarzer

In addition, Dr. Philipp Kügler (Industrial Mathematics Institute, Univ. of Linz) cooperates with the group in and advisory/supervisory role for specific projects.

Introduction by Group Leader Prof. Heinz W. Engl

In addition to the group leader, the group currently consists of 15 (senior) PostDocs and 5 doctoral students. Also, two members of the Industrial Mathematics Institute of JKU (Martin Burger, Philipp Kügler) contributed to the scientific work of the institute in an advisory role within externally funded projects. Prof. Burger, who is now a professor in Münster, still cooperates with us in the ion channel work: he co-advises Kattrin Arning, and Marie-Therese Wolfram, who spent the academic year 2006/07 with him in Münster, has returned to Linz and will finish her PhD thesis under the guidance of Prof. Burger.

Out of the 20 positions of the group, 5 are funded by the ÖAW. External funds come from

- the FWF in the framework of single projects, the SFB "Numerical and Symbolic Scientific Computing" and the Doctoral College "Molecular Bioanalytics"

- the Viennese fund WWTF for a project in systems biology jointly led by Christoph Flamm (University of Vienna) and the group leader.

The group was (and will continue to be) dealing with a wide variety of topics in inverse problems and related fields, especially control and imaging, as can be seen in more detail from the individual reports below and in the previous annual reports. These can be grouped into methodological and applications-oriented topics, with close relations between both.

On the methodological side, the work concerned
- regularization methods, both variational and iterative ones, for nonlinear inverse problems with an emphasis on implementable parameter choice strategies with optimal convergence properties (like the "balancing principle")
- theory of and use of sparsity in regularization methods
- regularization methods in a non-Hilbert space setting like Bregman iteration, maximum entropy and EM methods
- level set methods, BV and inverse scale space regularization, with close connections to imaging,
- a convergence theory (in distribution) for stochastic inverse problems including the first quantitative convergence results for Bayesian inversion, measured in the Prokhorov and Ky Fan metrics

Major application fields addressed were
- inverse problems in finance, where theory and numerics for identification in Levy models were developed in cooperation with the Finance Group
- inverse scattering
- parameter identification and inverse bifurcation problems in systems biology (where sparsity plays a major role)
- inverse problems for ion channels and biological membranes.

The last two points belong to the promising field of inverse problems in biology, which will be even by RICAM more emphasized in the future, also in connection with a possible group on mathematical methods in biology to be set up (at least partially) in Vienna, where there is a large need for cooperations with mathematicians as expressed e.g. by the directors of the biologically oriented Academy institutes (see Section 2.2).

In addition to Martin Burger, also Arnd Rösch received a call to a Full Professorship; he has assumed a Chair at the University of Duisburg-Essen on April 1, 2007. Two of is doctoral students (Cherednichenko, Krumbiegel) moved to Duisburg with him. Prof. Rösch will still advise Ms. Metla jointly with Dr. Griesse.

An interesting development occurred in the first half of 2007: Since the Austrian Ministry for Science and Research contemplated Austria's joining ESO (the "European Southern Observatory"), we were asked to formulate projects as possible in-kind contributions to ESO. Our proposals to contribute mathematical and numerical methods for Adaptive Optics were very well received by ESO and resulted in ESO accepting projects valued at more than € 2.000.000,-- as part of the Austrian in-kind contribution. It is not yet clear if the Ministry will finally decide to join ESO

The group has also been connected to all of the Special Semesters so far. In the Special Semester on Stochastics planned for 2008, one of the major topics will be stochastic methods for inverse and identification problem and their interplay with deterministic methods, which will also remain an important research topic for the group. For the spring of 2009, we plan a special semester on some aspects of inverse problems (see Section 3.1), which will lead into the international Applied Inverse Problems Conference (chaired by the group leader) to be held in Vienna in July 2009.

Dr. Jenny Niebsch

Dr. Niebsch joined the group in October 2007. Before, she worked on several industrial cooperation projects concerning the inverse imbalance reconstruction in rotating systems like aircraft engines (Rolls Royce), generators (Siemens AG), vacuum pumps (Oerlicon Leybold Vacuum GmbH), and wind power plants (Fielax GmbH, WindGuard Dynamics GmbH, Mysen GmbH).

Scientific Achievements 2007

Mathematical methods for high-precision balancing of machine-tools
The goal of the project is the development of a general model for the description of the attainable construction unit quality as a function of the imbalance state and the structure configuration by the example of ultra precision machining. Imbalance driven oscillations can lead to a significant decrease of the surface quality. We aim at the prognosis of the attainable workpiece quality during the process. The project is a co-operation with the University of Bremen.
Our task in the project is the development of an imbalance reconstruction method. The connection of an imbalance distribution and the resulting oscillations of a rotating system can be described mathematically by a (possibly nonlinear) differential equation. The reconstruction of an imbalance distribution or the determination of balancing weights from vibrational measurements is an inverse and ill – posed problem.

The project started in October 2007. The first task is the development of an FE model of an experimental platform located at the LFM in Bremen linking the imbalances to the machine vibrations. So far we collected vibrational data for given unit imbalance states of the platform. Assuming that the vibrational response to imbalances is linear, we can derive from the data a tranfer matrix that maps an arbitrary imbalance state to the vibrations at sensor positions. This experimental model serves as a comparision to the mathematical FE model. Additionally, we extracted the necessary geometric and physical data for the mathematical model of the rotor of the machine from a CAD model of the experimental platform and derived a first model (stiffness and mass matrix) for the rotational part.

The research is done in cooperation with R. Ramlau, Prof. Dr. Peter Maaß (University of Bremen), and the Laboratory for Precision Machining (LFM) Bremen, in the framework of the FWF project P20237-N14 of PD Dr. Ronny Ramlau.

Industrial Projects 2007

Improved balancing methods for vacuum pumps
In this project we constructed an experimental vibrational model of a vacuum pump of the company Oerlikon Leybold Vacuum GmbH, Germany. Based on the model we reconstructed given and unknown imbalances of the pump. The results were strongly influenced by measurement inaccuracies.
We suggested the development of a mathematical model in order to avoid this problem. Realizing such a model we should be able to compute the residual imbalance more accurately, and give better balancing suggestions.

Model optimization for rotating machinery at Siemens
At the Siemens AG Automation and Drives in Berlin there exist models for some of the produced engines. With software developed by Siemens, eigenfrequencies of the engines can be computed. The eigenfrequencies depend on several parameters of the model. For a safe operation it is necessary that the frequencies are not contained in certain ranges. Our task was the optimization of the parameters so that these conditions on the eigenfrequencies hold. The developed method was based on the Nelder-Mead algorithm. The work is still in progress.

Scientific Cooperations

Internal
PD Dr. Ronny Ramlau

External
Prof. Dr. Peter Maaß, University of Bremen, Zentrum für Technomathematik (ZeTeM);
Dr. Iwona Piotrowska, University of Bremen, ZeTeM;
Dipl.-Ing. Andreas Krause, University of Bremen, Laboratory for Precision Machining (LFM)

Industrial Cooperations

Dr. – Ing. M. Lang, Siemens GmbH, Automation and Drives, Berlin, Germany
Ing. M. Melzheimer Deutsche Windguard Dynamix GmbH, Berlin, Germany
Ing. H. Fritsch, MySen GmbH, Rudolstadt, Germany
Dr. G. Stüber, Oerlikon Leybold Vacuum GmbH, Cologne, Germany

Scientific Talk

„Mathematische Verfahren zur Präzisionswuchtung an Werkzeugmaschinen",
University of Bremen, 24.07.2007

Publication 2007

"Verbesserte Auswuchtung von Vakuumpumpen" for FA Oerlikon Leybold Vaccum GmbH Köln, Germany, Study Report

Submitted
J. Niebsch and R. Ramlau. "Automatic Imbalance Identification in Wind Turbines", submitted 11/2007

Prof. Dr. Sergei Pereverzyev

Achievements in the year 2007

In the year 2007, the three years research project "Fixed point regularization schemes for nonlinear ill-posed problems and their discretization" funded by FWF as the grant P17251-N12 has been finished. Within this project 2 PhD-students were employed for the past 3 years. In June 2007 one of them, Shuai Lu, successfully defended his doctoral dissertation. The second doctoral dissertation by Hui Cao was successfully defended in September 2007. Moreover, in April 2007, both of them were awarded with the Chinese Government Award for outstanding PhD-students abroad (300 persons from all branches of science worldwide received such an award endowed with 5000 USD).
The final report on this project was submitted to FWF for the referees' assessment. The conclusion of referees is positive. In particular they mention: "Es ist bemerkenswert, daß während der Zeit der Projektbearbeitung in einem kleinen Team eine Vielzahl theoretischer Ergebnisse erzielt wurden..."
These instances allow an estimation of the project as successfully realized one.
In the course of the project realization it became clear that the research activity of the project team could be extended in the following directions: a) Indirect regularization of ill-posed problems in non-Hilbert spaces by standard regularization methods; b) Regularization algorithms in learning theory; c) Parameter choice strategies for penalty methods of numerical analysis.
To attract additional funds for an extensive research in these directions the application for FWF-funding for the project "Indirect regularization in non-Hilbert spaces" was submitted in April 2007.

Recently this project has been awarded funding as the grant P20235-N18 (the total sum of the project is 276 097, 50 Euro). In this project we plan, in particular, to extend the balancing principle developed in the previous FWF-project to regularization in non-Hilbert spaces.
Moreover, we have taken an active part in the preparation of a large-scale integrating project "DIAdvisor – personal glucose predictive Diabetes Advisor". In September this project has been selected by European Commission for funding within in EU Seventh Research Framework Programme (FP7). As members of DIAdvisor-consortium responsible for mathematical part, we plan to study the possibility to apply regularized learning algorithms for therapy indications which use information about parameters hinting at a change in insulin resistance.
In the year 2007 jointly with Prof. U. Tautenhahn (University of Applied Sciences Zittau) we have obtained the results on regularized total least squares (RTLS). This technique is widely used for treating ill-posed operator equations when the right hand side and the operator are noisy. However, several important questions remain open. Our research shed light on the relationship between RTLS and the standard Tikhonov regularization. We have also proposed a new version of RTLS, which we call dual RTLS, and shown its advantage over the standard scheme. Moreover, for the first time, order optimal error bounds characterizing the accuracy of RTLS-approximations are provided. The results are presented in RICAM-Report 2007-30.

Scientific cooperations

Internal
- Dr. Eva Sincich:
  Research on nondestructive detection of a corrosion.

External
- PD Dr. Peter Mathe (Weierstrass-Institute, Berlin) and Prof. Dr. Bernd Hofmann (TU Chemnitz):
  Development of the concept of distance functions for analyzing regularization methods.
- Prof. Dr. U. Tautenhahn (University of Applied Sciences Zittau):
  Research on regularized total least squares.
- Prof. Dr. Phoolan Prasad (Indian Institute of Science, Bangalore):
  Research in progress on the sonic boom problem.
- Prof. Dr. M. Klibanov (University of North Carolina):
  Research in progress on quasi-reversibility method.

Publications 2007

1. F. Bauer, S. Pereverzyev, L. Rosasco, On Regularization Algorithms in Learning Theory. Journal of Complexity, 23 (1):52 - 72, 2007.
(the paper is listed now among Top 25 Hottest Articles published by Journal of Complexity
http://top25.sciencedirect.com/?journal_id=0885064X)

2. F. Bauer, P. Mathe, S. Pereverzyev, Local Solutions to Inverse Problems in Geodesy: The Impact of the Noise Covariance Structure upon the Accuracy of Estimation. Journal of Geodesy, 81 (1):39 - 51, 2007.

3 M. Thamban Nair, S. Pereverzyev, Regularized collocation method for Fredholm integral equations of the first kind. Journal of Complexity, 23 (4-6): 454-467, 2007.

4. R.D. Lazarov, S. Lu, S. Pereverzyev, On the balancing principle for some problems of Numerical Analysis. Numerische Mathematik, 106 (4):659 - 689, 2007.

5. S. Lu, S. Pereverzyev, R. Ramlau, An analysis of Tikhonov regularization for nonlinear ill-posed problems under general smoothness assumptions. Inverse Problems, 23 (1):217 – 230, 2007.

6. H.Cao, S.V. Pereverzyev, The balancing principle for the regularization of elliptic Cauchy problems. Inverse Problems, 23(5):1943-1961, 2007.

7. B. Hofmann, P. Mathe, S. Pereverzev, Regularization by projection: Approximation theoretic aspects and distance functions. Journal of Inverse and Ill-posed Problems, 15(5):527-545, 2007.

Scientific Visits, participation in conferences in 2007

- May, 14 – May, 25: Invited lecture course „Regularization methods for ill-posed problems of analysis and statistics“ within 6-th EU Framework Programme “Transfer of Knowledge”, Stefan Banach International Center in Warsaw (Poland).
- June, 25 – June, 29: First International Congress of IPIA, Vancouver, Canada: Invited minisymposium talk.
- July, 16 – July, 20: 6-th International Congress on Industrial and Applied Mathematics, Zürich, Switzerland: Organizer of the minisymposium “Non-standard and problem-oriented regularization methods”. Invited talk in the minisymposium “Inverse Problems in Industry”.

Dr. Hui Cao

Scientific Achievements 2007

Natural linearization allows a reduction of nonlinear inverse problem to a finite sequence of linear ones. We have shown that this technique can be also applied to a classical ill-posed problem, namely an elliptic Cauchy problem. After natural linearization, self-regularization can be applied to deal with the severe ill-posedness of the Cauchy problem, where the discretization plays the role of regularization. The balancing principle as an adaptive strategy has been studied to select an appropriate discretization level without quantitative knowledge of a rate of convergence or a degree of stability.

Moreover, in cooperation with Dr.Eva Sincich the natural linearization scheme has been extended to the corrosion detection problem, where the goal is to determine a possible presence of corrosion damage by performing current and voltage measurements on the boundary. It can be naturally linearized and reduced to an elliptic Cauchy problem. Therefore, the previously developed techniques can be applied.

Scientific Cooperation

Internal
Prof. Dr. Sergei V Pereverzyev
Dr. Eva Sincich

External
Prof. Dr. Michael Klibanov, University of North Carolina at Charlotte

Participation at Conference

ICIAM 2007 in Zurich, contributed talk with the title of ‘‘Balancing principle for solving naturally linearized elliptic Cauchy problems’’

Publications 2007

Appeared
Cao H and Pereverzev S V 2007 Balancing principle for the regularization of elliptic Cauchy problems Inverse Problems 23 1943—61

Submitted
Cao H, Pereverzev S V and Sincich E 2007 Natural linearization for corrosion identification

Awards and PhD Program

Awards
Chinese government award for outstanding self-financed students abroad for 2006. (The awards ceremony took place in 2007)

PhD Program
Passed my PhD defence at September 2007.

Dr. Shuai Lu

Jan. 07–Aug. 07: Member of the Inverse Problems Group of RICAM, under the FWF-Project P17251-N12 “Fixed point regularization schemes for nonlinear ill-posed problems and their discretization”
Sep. 07– Now: Member of the Inverse Problems Group of RICAM, under the FWF-Project P20235-N18 “Indirect regularization in non-Hilbert spaces”

Scientific Achievements 2007

Sparse reconstruction using the standard Tikhonov method
It is a common belief that Tikhonov regularization with L2-penalty fails in sparse reconstruction. We show, however, that for some operators this standard regularization can help if the stability measured in the L1-norm will be properly taken into account in the choice of the regularization parameter. We extend our results to the case when the unknown solution admits a sparse representation in both orthonormal and non-orthonormal systems. The results also show that with different operators and bases, the degree of stability is different in the L1-norm compared with the fixed degree of stability in the L2-norm. A sample based procedure and a Monte Carlo method based procedure are implemented to estimate the stability term. The testing examples show that we can reconstruct the support of the sparse solution very well under the new L1-norm adaptation procedure.

Regularized total least squares
For solving linear ill-posed problems regularization methods are required when the right hand side and the operator are with some noise. We study the case, when regularized approximations are obtained by regularized total least squares and dual regularized total least squares. We discuss computational aspects and provide order optimal error bounds that characterize the accuracy of the regularized approximations. The results extend earlier results where the operator is exactly given. We also present some numerical experiments, which shed a light on the relationship between RTLS, dual RTLS and the standard Tikhonov regularization.

Scientific Cooperations

Internal
Prof. Dr. Pereverzyev
PD Dr. Ramlau

External
Prof. Lazarov (Texas A & M University)
Prof. Tautenhahn (Hochschule Zittau/Görlitz)

Participation at Conferences, Scientific Visits and Talk

Scientific Visits
- International BioMathematics Workshop (12-15 Feb 2007) Shanghai China
- 6th International Congress on Industrial and Applied Mathematics (16-20 July 2007) Zurich Switzerland

Publications 2007

- S Lu, S Pereverzev, R Ramlau, An analysis of Tikhonov regularization for nonlinear ill-posed problems under general smoothness assumption, Inverse Problem, 23 (2007), 217-230 .
- R Lazarov, S Lu, S Pereverzev, On the balancing principle for some problems of Numerical Analysis, Numerische Mathematik, 106 (2007), 659-689.
- S Lu, S Pereverzev, Sparsity reconstruction by the standard Tikhonov regularization, submitted.
- S Lu, S Pereverzev, U Tautenhahn, Regularized total least squares: computational aspects and error bounds, submitted, Ricam report 2007-30.
- S Lu, S Pereverzev, Sparse reconstruction by means of the standard Tikhonov regularization, abstract accepted by 6th International Conference on Inverse Problems in Engineering, 2008.

Ph.D. Dissertation

A balancing principle for the choice of the regularization parameter
Defended on June 14 2007 (referees: Prof. Engl, Prof. Pereverzyev)

Dr. Sergiy Pereverzyev jun.

Work before joining RICAM

Pereverzyev jun. has defended his PhD thesis "Method of Regularized Fixed-Point and its Application" in the Technical University of Kaiserslautern on October 23, 2006. His referees were Prof. Rene Pinnau and Prof. Heinz W. Engl. After defense and before coming to RICAM, Pereverzyev jun. was working in the Technical University of Kaiserslautern, Department of Mathematics in the DFG-Project "Optimal control and inverse problems in radiative heat transfer" within the framework of the DFG-Priority Program "Optimization with Partial Differential Equations".

Scientific Achievements 2007 (September 1 – December 31, 2007)

Since his working start in RICAM, Pereverzyev jun. actively participated in the workshops of the Special Semester on Quantative Biology analyzed by Mathematical Methods. He worked on mathematical modeling of pattern formation in the leaf development with the long term visitor of the

Special Semester Prof. Bob Anderssen (CSIRO, Australia). The goal was to develop a simple, clear, and biologically accpetable algebraic model of distribution of special features on the tissues based on the recently obtained knowledge in the genetics of pattern formation in plants. A particular application is modeling trichomes distribution in the widely used model plant Arabidopsis. Results of the work will be presented in the final workshop of the Special Semester "Pattern Formation and Functional Morphology" in January 2008.

Also, Pereverzyev jun. was working on developing and analyzing derivative-free iterative methods for nonlinear inverse problems. Results of the work have been presented in a RICAM report and submitted to the 6th International Conference on Inverse Problems in Engineering that will be held in June 2008.

Scientific Cooperations

External
Prof. Bob Anderssen (CSIRO, Australia)
Prof. Rene Pinnau (TU Kaiserslautern, Germany)
Dr. Norbert Siedow (ITWM, Germany)

Dr. Ronny Ramlau

Scientific Achievements 2007

Regularization of nonlinear ill – posed problems with sparsity constraints (FWF Project):
In the previous years, we have investigated Tikhonov regularization with one – homogeneous sparsity constraints, and have presented an iterative optimization strategy for the minimization of the functional. The method is based on so called surrogate functionals, where the original functional is replaced by a sequence of approximating functionals with better properties. In [7], this approach was extended to vector valued data. For the reconstruction, a joint sparsity term was used, which forces the different channels to have e.g. jumps at the same locations.
Besides the investigation of the convergence properties of the used optimization method, we also investigated an a – priori parameter choice rule for a special penalty term. The method was successfully applied to the Color Inpainting Problem, i.e. the reconstruction of a full color image from a given noisy grayscale picture and partial, but exact color information. The proposed algorithm was applied to a real life art restoration problem, and its performance was compared to a TV – based reconstruction [9]. Since November, Dipl.–Ing. Stephan Anzengruber is employed in the framework of the FWF project P19496-N18. Currently, he makes himself familiar with the basic mathematical knowledge necessary to achieve the project aims.

Mumford-Shah Models for the Inversion of Tomography Data (FWF-Project)
The research on the FWF project P19029-N18 is done in cooperation with E. Klann, W. Ring (University of Graz) and E. Hoetzl (University of Graz). With the Mumford-Shah approach we aim at a stable inversion of tomography data (CT, SPECT) and a simultaneous segmentation of the reconstruction. In 2007 we have been concentrating on the SPECT problem modeled by the nonlinear attenuated Radon transform. In particular, we have studied minimization approaches for a Mumford – Shah functional where we assumed that both SPECT and CT data were available. Assuming that the solution is piecewise constant, we computed the optimal functional values for fixed geometry by Newton's method, and obtained a shape update by the level set method. The required speed function was obtained via the shape derivative of the Mumford – Shah functional. The resulting algorithm was implemented and first successful test computations were carried out. Moreover, we investigated the

regularization properties of the Mumford – Shah functional and proposed a parameter choice rule that ensures convergence of the method.

Two-step methods for ill-posed problems
The general idea of two-step methods for ill-posed problems is to combine a data-adapted smoothing step and an operator-adapted reconstruction step. In this context we have started a cooperation with L. Reichel (Kent State University) on the combination of wavelet shrinkage as data smoothing and Krylov-space methods for the reconstruction.

Blind deconvolution
In 2006, we have published a paper on the reconstruction of both the image and the kernel function from their convolution product. The solution operator is continuous as long as the data has a certain smoothness property, which is usually not the case for noisy data. Therefore, we developed in [8] a regularization method, namely the continuous Fourier Shrinkage, that maps the noisy data to the range of the convolution operator. For the regularization, we proposed a priori and a posteriori parameter rules and showed convergence and convergence rates of the method.

Inverse Imbalance Reconstruction (also a new FWF project)
After developing regularization methods for the reconstruction of imbalance distributions in rotating systems, the focus was this year mainly on the application of the developed methods to vacuum pumps, where a study for the company Oerlikon Leybold Vacuum was done. At the end of October 2007, Dr. Jenny Niebsch was employed by the Academy in order to start a joint project with the University of Bremen on the development of balancing methods for high precision machine tools. Starting January 1, 2008 she will continue to work on this project in the framework of the FWF project P20237-N14.

Grants

FWF – Project P19029-N18
Title: Mumford – Shah – Models in Tomography
Project Leader: PD. Dr. R. Ramlau and Prof. Dr. W. Ring (Graz)
Project members: Dr. Esther Klann (RICAM) and Mag. Rer. Nat. E. Hötzl (Graz)
Project start: July 2006

FWF – Project P19496-N18
Title: Sparse Reconstructions in Inverse Problems
Project Leader: PD. Dr. R. Ramlau
Project members: Stephan Anzengruber
Project start: June 2007

FWF – Project P20237-N14
Title: Mathematical methods for high-precision balancing of machine-tools
Project Leader: PD. Dr. R. Ramlau
Project members: Dr. Jenny Niebsch
Project start: January 2008

Scientific Cooperations

Internal
Dr. Esther Klann
Dr. Stefan Kindermann
Prof. Dr. Andreas Neubauer

Prof. Sergei Pereverzyev
Dr. Shui Lu
Dr. Massimo Fornasier (RICAM/Princeton)
Dr. Elena Resmerita
Dr. Jenny Niebsch

External
Prof. Dr. Wolfgang Ring, University of Graz, Austria
Mag. rer. nat. Elena Hötzl, University of Graz, Austria
PD Dr. Gerd Teschke, Konrad – Zuse Institute, Berlin, Germany
Dipl. Math. Mariya Zharyi, Konrad – Zuse Institute, Berlin, Germany
Prof. Dr. Peter Maass, University of Bremen, Germany
Dr. Lutz Justen, University of Bremen, Germany
Prof. Dr. E. Brinksmeier, Laboratory for Precision Machining, University of Bremen, Germany
Prof. Dr. Martin Burger, University of Münster, Germany
Prof. Dr. F. Noo, Utah Center for Advanced Imaging Research, University of Utah, Salt Lake City, USA
Prof. Dr. Rolf Clackdoyle, Laboratoire Traitement du Signal et Instruments (CNRS UMR 5516), St. Etienne, France
Prof. Dr. L. Reichel, Kent State University, Kent, USA
Prof. Dr. Antonio Leitao, Federal University of Santa Catarina, Brazil
Dr. Frank Bauer, Kepler – University, Linz, Austria

Industrial Cooperations

Dr. – Ing. M. Lang, Siemens GmbH, Automation and Drives, Berlin, Germany
Ing. M. Melzheimer Deutsche Windguard Dynamix GmbH, Berlin, Germany
Ing. H. Fritsch, MySen GmbH, Rudolstadt, Germany
Dr. G. Stüber, Oerlikon Leybold Vacuum GmbH, Cologne, Germany

Participation at Conferences, Scientific Visits and Talk

Conferences
- International Workshop on Image Analysis in the Life Sciences, Linz, Austria, February 28 – March 2
- Optimal Algorithms and Computational Complexity for Numerical Problems, Salt Lake City, USA, May 6 – May 8
- Applied Inverse Problems, Vancouver, Canada, June 25 – June 29
- ICIAM 2007, Zurich, Switzerland, July 16 – 20
- Adaptive Numerical Methods for Inverse Problems, August 27-28, Centre of
- Industrial Mathematics, University of Bremen, Germany
- Workshop on Bioimaging / PDEs, Linz, Austria, November 19 – 23

Scientific Visits
- University of Utah, Salt Lake City, USA, May 1 – May 10 (Prof. Dr. F. Stenger)
- Konrad – Zuse Institute, Berlin, Germany, July 31 – August 2 (Dr. Gerd Teschke)
- Karl – Franzens – University Graz, Austria, November 6 – 8 (Prof. Ring)

Scientific Talks
- New regularization approaches for tomography, International Workshop on Image Analysis in the Life Sciences, Linz, Austria, March 2, 2007

- Regularization of Inverse Problems using Sparsity Constraints – Analysis and Applications, RICAM Kuratorium Meeting, Linz, April 30, 2007
- Regularization of Inverse Problems with Sparsity Constraints, Optimal Algorithms and Computational Complexity for Numerical Problems, Salt Lake City, USA, May 6
- Blind Deconvolution – Ill-posedness and regularization aspects, Applied Inverse Problems Conference, Vancouver, Canada, June 26
- Regularization of Inverse Problems with Sparsity Constraints, Applied Inverse Problems Conference, Vancouver, Canada, June 28
- Nonlinear Regularization Methods for the Solution of Linear Ill – Posed Problems, FWF Hearing, Wien, July 12
- Simultaneous Reconstruction and Segmentation for Tomography Data, ICIAM 2007, Zurich, Switzerland, July 16 – 20
- Regularization by two step methods, Workshop on Adaptive Numerical Methods for Inverse Problems, University of Bremen, August 28
- Simultaneous Segmentation and Reconstruction of Tomography Data, Workshop on Bioimaging / PDEs, Linz, November 21

Publications 2007

Appeared / Accepted

[1] S. Lu, S. Pereverzyev, R. Ramlau, An analysis of Tikhonov regularization for nonlinear ill-posed problems under general smoothness assumptions, Inverse Problems 23 No 1 (February 2007) 217-230

[2] R. Ramlau, R. Ring, A Mumford-Shah approach for contour tomography, J. Comp. Physics 221 (2007), 539 - 557

[3] S. Kindermann, R. Ramlau, Surrogate Functional and Tresholding for Inverse Interface problems, J. Inv. Ill – Posed Problems,15(4), (July 2007), 387 – 402

[4] R. Ramlau and G. Teschke, An Iterative Algorithm for Nonlinear Inverse Problems with Joint Sparsity Constraints in Vector Valued Regimes and an Application to Color Image Inpainting, Inverse Problems 23(5), 1851 – 1870, 2007

[5] L. Justen and R. Ramlau , A General Framework for Soft – Shrinkage with Applications to Blind Deconvolution and Wavelet Denoising, to appear in Applied and Computational Harmonic Analysis

Submitted

[6] J. Niebsch, R. Ramlau, Automatic Imbalance Identification in Wind Turbines, submitted for publication

[7] R. Ramlau, Regularization Properties of Tikhonov Regularization with sparsity constraints, submitted for publication

[8] E.Klann and R.Ramlau. Regularization by Fractional Filter Methods and Data Smoothing, submitted for publication.

[9] M. Fornasier, R. Ramlau and G. Teschke. A comparison of joint sparsity and total variation minimization algorithms in a real life art restoration problem, submitted for publication

Stephan Anzengruber advised by Dr. Ronny Ramlau

Work before joining RICAM

Stephan Anzengruber finished his studies of "Technische Mathematik" in November 2007 at the Johannes Kepler University Linz. Since then he is working in the framework of the FWF Project P19496-N18 as a Ph.D. student advised by Prof. Dr. Ronny Ramlau. Most of this year's work was dedicated to his diploma thesis on 'Curvelets, Pseudodifferential-Operators and the Wave Front Set', where he worked on the propagation of singularities, characterized through the wave front set, in the

presence of pseudodifferential operators and showed how the directional curvelet transform can be used to compute the wave front set.

Scientific Achievements 2007

In the month that he's been employed, Stephan Anzengruber has worked on a joint project with Dr. Bauer (Hagenberg), the Brazilian RICAM visitor Prof. Leitao and Dr. Ramlau on applying the method of surrogate functionals to the reconstruction of MRI images. Meanwhile he also continued to make himself familiar with the existing literature on regularization of inverse problems using sparsity constraints.

Participation at Conferences, Scientific Visits and Talks Conferences (including talks)

Dolomites Research Week on Approximation '07, 03.-07.09.2007, Alba di Canazei (Italy)

Dr. Esther Klann

Scientific Achievements 2007

Mumford-Shah Models for the Inversion of Tomography Data (FWF-Project)
The Mumford-Shah approach aims at a stable inversion of the data and a simultaneous segmentation of the reconstruction. In 2007 we have been concentrating on the SPECT problem modeled by the nonlinear attenuated Radon transform. The corresponding Mumford-Shah like functional is acting on two functionals, the activity and the density distribution, which are nonlinearly linked by the attenuated Radon transform. Density as well as activity distribution are modeled by a geometric variable (set of domains) and a set of function values. The Mumford-Shah like functional has to be minimized with respect to both the geometrical and the functional variable. Our approach to this optimization problem is to fix one of the variables (i.e. either the geometry or the function values) and minimize with respect to the other (i.e. the functional values or the geometry) and vice versa. For the minimization with fixed geometry we have computed the optimality system which is nonlinear. A first implementation and some test calculation using the standard Newton method have been done. For the minimization with fixed function values we have analytically computed a descent direction. A first implementation of the geometry update is working and a successful test reconstruction from exact, generated data has been done.
The research is done in cooperation with R. Ramlau, W. Ring (University of Graz) and E. Hoetzl (University of Graz) in the framework of the FWF project P19029-N18 of PD Dr. Ronny Ramlau.

Two-step methods for ill-posed problems
We have started a cooperation with L. Reichel (Kent State University) on two-step methods for the solution of ill-posed problems. The general concept of two-step methods is the combination of a data smoothing and a reconstruction operation. In [2] we studied the special combination of fractional filter methods and wavelet shrinkage. In the cooperation with Prof. Reichel we consider wavelet shrinkage as data smoothing and Krylov-space methods for the reconstruction. The crucial step for two-step methods is the link between the smoothing and the reconstruction operator. Some first numerical experiments have been done on wavelet shrinkage and Krylov-methods.

Convective mass transfer in cake cooking
A cake is produced by cooking a batter in a (hot) oven. By using food coloring, we observed that in this process heat convection takes place. In order to model this physical process, we started a joint project together with Prof. Anderssen, who is a guest of the 'Special Semester on Quantitative Biology analyzed by Mathematical Methods' and did research on dough rheology.

Scientific Cooperations

Internal
PD Dr. Ronny Ramlau

External
Prof. Dr. Bob Anderssen, CSIRO Mathematical and Information Sciences, Canberra, Australia
Prof. Dr. Peter Maass, University of Bremen, Germany
Prof. Dr. Lothar Reichel , Kent State University, Ohio, USA
Prof. Dr. Wolfgang Ring, University of Graz, Austria
Dr. Dirk Lorenz, University of Bremen, Germany
Mag. rer. nat. Elena Hötzl, University of Graz, Austria

Participation at Conferences, Scientific Visits and Talks

Conferences
- AIP 2007, June 25-29, 2007 Vancouver, Canada
- ENUMATH 2007, September 10-14, 2007, University of Graz, Austria
- Adaptive Numerical Methods for Inverse Problems, August 27-28, Centre of Industrial Mathematics, University of Bremen, Germany

Scientific Visits
University of Graz, April 11-14, 2007, (Prof. Dr. Wolfgang Ring)
University of Graz, November 6-8, 2007, (Prof. Dr. Wolfgang Ring)

Scientific Talks
- On: Inverse Problems with General Convex Constraints, Iteratively Solving Linear Inverse Problems under General Convex Constraints, by Ingrid Daubechies, Gerd Teschke and Luminita Vese, Industrial Mathematics Seminar, Johannes Kepler Universität Linz, Austria, June 13, 2007
- Simultaneous Reconstruction and Segmentation for Tomography Data, AIP 2007, June 29, Vancouver, Canada
- Simultaneous Reconstruction and Segmentation for Tomography Data, Adaptive Numerical Methods for Inverse Problems, August 28, Centre of Industrial Mathematics, University of Bremen, Germany
- Regularization by Fractional Methods and Data Smoothing, ENUMATH 2007, September 12, University of Graz, Austria

Publications 2007

Published
[1] D.Lorenz, E.Klann, M.Kuhn, P.Maass and H.Thiele. *Shrinkage versus Deconvolution.* Inverse Problems, Bd. 23 (5), S. 2231-2248, 2007.

Submitted
[2] E.Klann and R.Ramlau. Regularization by Fractional Filter Methods and Data Smoothing.
[3] E.Klann, R.Ramlau and W. Ring, A Mumford-Shah Level-Set Approach for the Inversion and Segmentation of SPECT Data. (in preparation).

Dr. Elena Resmerita

Scientific Achievements 2007

Elena Resmerita (ER) has continued her work on regularization of ill-posed operator equations in Banach spaces.
In cooperation with M. Burger and L. He, ER has obtained convergence rates for Bregman iterations and inverse scale space methods for image restoration in the space of bounded variation functions. The corresponding manuscript [3] was completed and submitted.
ER has studied the EM algorithm for image reconstruction in positron emission tomography (PET). This algorithm has a simple form, being frequently used in practice. However, it behaves very unstably under noisy data. Thus, in collaboration with H. Engl and A. Iusem, ER has considered the algorithm in an infinite dimensional setting and approached it via regularization [4]. While no convergence results have been shown until now under these circumstances, ER and the collaborators have established weak convergence of the algorithm and proposed a stopping rule which shows that the iterative procedure approximates stably solutions of the equation when the noise level goes to zero.
The collaboration with D. Butnariu on optimization topics in infinite dimensional spaces continued, resulting in the paper [5].

In addition, Elena Resmerita has prepared a proposal for an FWF "Elise Richter" grant, which promotes women towards academic careers. The project proposal, titled "Regularization of ill-posed problems in Banach spaces", was submitted to FWF in May 2007 and was approved in December, the same year. It will start in June 2008 and will be developed within the Industrial Mathematics Institute, J.K. University of Linz (the Elise Richter program requires affiliation with a university, and not with an institute of the Academy).

Scientific Cooperations

Internal
Prof. Heinz Engl - J. Kepler University of Linz and RICAM
Dr. Lin He – J. Kepler University of Linz and RICAM
Dr. Ronny Ramlau - RICAM
Prof. Otmar Scherzer – University of Innsbruck and RICAM

External
Dr. Robert S. Anderssen - CSIRO Mathematical and Information Sciences, Canberra, Australia
Prof. Martin Burger – University of Münster, Germany
Prof. Dan Butnariu - University of Haifa, Israel
Prof. Alfredo Iusem – Instituto de Matematica Pura e Aplicada, Rio de Janeiro, Brasil

Participation at Conferences, Scientific Visits and Talks

- Invited talk in a special session at the AMS-MAA Joint Mathematics Meeting, New Orleans, USA, January 5-8, 2007. Convergence rates for non-quadratic regularization of nonlinear inverse problems.
- Talk in the "Inverse Problems" Seminar, RICAM, Linz, March 2007. Error estimations for Bregman iterations (joint talk with Lin He).
- Invited talk in a special session at the Joint EUROPT-OMS Meeting, Prague, Czech Republic, July 4-7, 2007. A proximal method for image restoration: Error estimation.
- Invited talk in a special session at the 6th International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, July 16-20, 2007. The EM algorithm for PET: A regularization approach.

- Talk in a special session at the 6th International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, July 16-20, 2007. A perspective on Bregman distances, Bregman projections and their applications.

Publications 2007

Appeared
[1] E. Resmerita and R.S. Anderssen: Joint additive Kullback-Leibler residual minimization and regularization for linear inverse problems, Mathematical Methods in the Applied Sciences, 30(13) (2007) 1527-1544.
[2] D. Butnariu and E. Resmerita: Mosco stability of proximal mappings in reflexive Banach spaces, Journal of Nonlinear and Convex Analysis, 8(1) (2007) 1-10.

[3] Error estimation for Bregman iterations and inverse scale space methods in image restoration (with M. Burger and L. He), Computing, 8 (2007) 109-135.

[4] The EM algorithm for ill-posed integral equations: a convergence result and a stopping rule (with H. Engl and A. Iusem), Inverse Problems, 23 (2007) 2575-2588.

Accepted
[5] D. Butnariu, E. Resmerita and S. Sabach, A Mosco stability theorem for generalized proximal mappings, Contemporary Mathematics, to appear, 2008.

Activities as a mentor/organizer/teacher

1. Mentored a RICAM - ICIAM grant receiver: Dr. Gert Tamberg, Tallinn University of Technology, Estonia), July 2-13, 2007.

2. Co-organized the interdisciplinary mini-symposium “Bregman distances in optimization, inverse problems and financial mathematics” at the 6th International Congress on Industrial and Applied Mathematics (ICIAM), Zurich, Switzerland, July 16-20, 2007 (together with Hansjoerg Albrecher, RICAM).

3. Course and seminar for “Mathematics for Chemists I”, Winter Semester 2007 - J.K. University of Linz (3 hours/week).

Prof. Arnd Rösch

Positions

I accepted an offer for a full professorship (W3) at the University Duisburg-Essen. My position in Linz finished at March 31, 2007. However, I am still leader of two FWF research projects at RICAM in Linz.

Scientific Achievements 2007

The research in the year of 2007 was focused on several mathematical fields:

1. Regularity of adjoint variables - Regularization of state constrained optimal control problems
Adjoint equations and the regularity of their solutions play an important role in the theories of inverse problems and optimal control. A new general result on existence of regular Lagrange multipliers was published in a joint paper with F. Tröltzsch (TU Berlin). Moreover, higher regularity for the optimal control was shown. Mixed constrained optimal control problems occur as regularized state constrained

problems. A joint paper with Klaus Krumbiegel on the virtual control approach was accepted during this period. A second paper improving these results is submitted.

2. Numerical analysis
We studied the discretization error for several situations. A new result concerning superconvergence of optimal control for control constrained problems was published in a joint paper with R. Simon (SFB 013 Linz). In a joint paper with Svetlana Cherednichenko we derived several error estimates for the finite element discretization of state constrained optimal control problems.

3. Nonlinear problems
Based on our work on Lipschitz stability of optimal solutions with respect to perturbations, Roland Griesse, Nataliya Metla, and I established a convergence theory for the SQP method for optimal control problems with control constraints and mixed constraints.

Scientific Cooperation

Internal
Roland Griesse (Group Optimisation and Control)
Boris Vexler (Group Optimisation and Control)

External
Prof. F. Tröltzsch (TU Berlin)
Prof. W. Alt (FSU Jena)
Prof. M. Mateos (Oviedo)
Dipl.-Math. D. Wachsmuth (TU Berlin)
Dipl.-Ing. C. Meyer (TU Berlin)
Dipl.-Math. R. Simon (SFB 013 Linz)
Prof. T. Apel (Universität der Bundeswehr München)
Dipl.-Math. G. Winkler (Universität der Bundeswehr München)
Prof. M. Hinze (Universität Hamburg)

Participation at conferences

- WONAPDE, Concepcion, January 16-19, 2007.
- Spring school, Linz, March 5-6, 2007
- Workshop Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen,
- Linz, March 7-9, 2007
- Annual Meeting of the DMV March 26-28, 2007.
- Spring School Catania, May 16-19, 2007.
- SIAM Conference on Control and its applications, San Francisco, June 29-July 1, 2007.
- ICIAM Zurich, July 16-20, 2007.
- IFIP Cracow, July 23-27, 2007.
- Enumath Graz, September 10-14, 2007.
- FEM Symposium Chemnitz, September 24-26, 2007
- Chemnitz Symposium on Inverse Problems, September 27-28, 2007
- Jahrestagung SPP 1253 Bad Honnef, October 4-5, 2007

Publications

Appeared

- A. Rösch, R. Simon, Superconvergence properties for optimal control problems discretized by piecewise linear and discontinuous functions, Numerical Functional Analysis and Optimization, 28(3):425--443, 2007.
- A. Rösch, F. Tröltzsch, On regularity of solutions and Lagrange multipliers of optimal control problems for semilinear equations with mixed pointwise control-state constraints, SIAM Journal Control and Optimization, 46(3):1098—1115, 2007.
- K.Krumbiegel, A.Rösch, A virtual control concept for state constrained optimal control problems, accepted for publication in Computational Optimization and Applications
- W. Alt, N. Bräutigam, and A. Rösch. Error estimates for finite element approximations of elliptic control problems. Discussiones Mathemaciae Differential Inclusions, Control and Optimization 27: 7-22, 2007.

Submitted

- R. Griesse, N. Metla, A. Rösch, Local Quadratic Convergence of SQP for Elliptic Optimal Control Problems with Mixed Control-State Constraints, submitted, 2007.
- A. Rösch and D. Wachsmuth, Semi-smooth Newton Method for an optimal control problem with control and mixed control-state constraints.
- K. Krumbiegel and A. Rösch. A new stopping criterion for iterative solvers for control constrained optimal control problems.
- K. Krumbiegel and A. Rösch. On the regularization error of state constrained Neumann control problems. Eingereicht bei Control and Cybernetics.
- S. Cherednichenko and A.~Rösch. Error Estimates for the Discretization of Elliptic Control Problems with Pointwise Control and State Constraints.

Talks

- A. Rösch, A virtual control concept for optimal control problems with pointwise state constraints. WONAPDE, Concepcion, Junary 16-19, 2007.
- A. Rösch, Approximation und Regularisierung von Optimalsteuerproblemen, Spring school, Linz, March 5-6, 2007.
- A. Rösch, On saturation effects in the discretization of Neumann boundary control problems. Workshop Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen, Linz, March 7-9 2007.
- A. Rösch, A virtual control concept for optimal control problems with pointwise state constraints. annual meeting of the DMV, Berlin, March 27, 2007.
- S. Cherdnichenko, N. Metla, and A. Rösch, Approximation and Regularization of Optimization Problems Governed by Partial Differential Equations}, RICAM Scientific Board Meeting, March 29, 2007.
- A. Rösch, Series of Lectures on Optimal Control, Spring School Catania, May 16-19, 2007.
- A. Rösch, Über Optimierungsprobleme bei partiellen Differentialgleichungen mit Zustandsbeschränkungen Institutskolloquium Bayreuth, June 21, 2007.
- A. Rösch, On the finite element approximation of elliptic optimal control problems with Neumann boundary control. SIAM Conference on Control and its applications, San Francisco, June 29-July 1, 2007.
- A. Rösch , A virtual control concept for optimal control problems with pointwise state constraints, ICIAM Zurich, July 16-20, 2007.
- A. Rösch, About nonuniform grids in control constrained optimal control problems. IFIP Cracow, July 23-27, 2007.
- A. Rösch , A virtual control concept for optimal control problems with pointwise state constraints, ENUMATH Graz, September 10-14, 2007.

Activities

- Organization of a spring school Linz, March 5-6, 2007 and the workshop Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen, Linz, March 7-9 2007 (together with T. Apel and B. Vexler).
- Organization of a minisymposium "Numerical methods for optimization problems with PDE constraints " on the SIAM Conference on Control and its applications, San Francisco, June 29-July 1, 2007 (together with B. Vexler).
- Organization of a minisymposium "PDE-constrained optimization: numerical analysis and sientific computing" on the ICIAM, Zurich July 16-20, 2007 (together with R. Griesse).

Projects

- FWF-Project P18056-N12 SSC and SQP for mixed constrained optimal control problems (joint project with Roland Griesse), positions: Nataliya Metla (1PhD)
- FWF-Project P 18090-N12 Approximation of optimal control problems governed by PDEs, positions: Svetlana Cherednichenko, Klaus Krumbiegel (2PhDs)
- FWF-Project P 18971-N18 Numerical analysis and discretization strategies for optimal control problems with singularities (joint project with B. Vexler and T. Apel (Munich), part
- of the DFG priority program 1253) positions: Olaf Benedix (1PhD)

Svetlana Cherednichenko advised by Prof. Arnd Rösch

Position

I finished my work at RICAM on 30.06.2007. Since 01.07.2007 I work at the University Duisburg-Essen.

Scientific Achievements 2007

We analyzed superconvergence effects for linear-quadratic optimal control problems with pure control constraints. Our goal is to employ a linear Ansatz function for the discretization of a space of controls. For a control constructed in a postprocessing step, numerical results show the expected quadratic convergence.
We considered optimal control problems with pure pointwise state constraints and their regularized versions. A theoretical base for estimation of the regularization error was established and numerically tested.

Scientific Cooperations

Internal
DI. K. Krumbiegel (Group Inverse Problems)
MSc. N. Metla (Group Inverse Problems)
Prof. Dr. A. Rösch (Group Inverse Problems)
Dr. B. Vexler (Group Optimization and Optimal Control)

External
Dr. C. Meyer, Weierstrass Institute for Applied Analysis and Stochastics (WIAS)

Participation at Conferences, Scientific Visits and Talks

Conferences
- Optimization methods, approximation, and adaptivity for optimal control problems governed by partial differential equations: Spring School, 5-6/03/2007, Linz; Workshop, 7-9/03/2007, Linz.
- Austrian Numerical Analysis Days, Vienna, 26-27/04/2007.
- 23rd IFIP TC 7 Conference on System Modelling and Optimization, Cracow, Poland, 23-27/07/2007.
- International Conference on Continuous Optimization, McMaster University, Hamilton, Ontario, Canada, 13-16/08/2007.

Scientific Talks
- Approximation and regularization of optimization problems governed by partial differential equations. RICAM Scientific Board Meeting, Linz, 29/03/2007.
- Regularization and discretization of state constrained optimal control problems. Austrian Numerical Analysis Days, Vienna, 26-27/04/2007.
- Regularization and discretization of constrained optimal control problems. 23rd IFIP TC 7 Conference on System Modelling and Optimization, Cracow, Poland, 23-27/07/2007.
- Regularization and discretization of constrained optimal control problems. International Conference on Continuous Optimization, McMaster University, Hamilton, Ontario, Canada, 13-16/08/2007.

Publications

Appeared
S. Cherednichenko and A. Rösch. Error estimates for the regularization of optimal control problems with pointwise control and state constraints. Journal for Analysis and its Applications, accepted for publication.

Submitted
S. Cherednichenko and A. Rösch. Error estimates for the discretization of elliptic control problems with pointwise control and state constraints.

Klaus Krumbiegel advised by Prof. Arnd Rösch

Position

I finished my work at RICAM at 30.06.2007. Since 02.07.2007 I work as a research assistent at the University Duisburg-Essen.

Scientific Achievements 2007

In a joint work with I. Yousept we adopted the strategy of error estimates for feasible solutions of optimal control problems to such problems with mixed control-state constraints. Furthermore, we will apply this concept also to other iterative solution methods for optimal control problems.

Moreover, we used a new approach for the virtual control concept, which we had introduced last year for state constrained optimal control problems with boundary control. This increases the efficiency of calculating optimal solutions. In a joint work with C. Meyer we investigated first results for the finite element error analysis of the regularized problem using the virtual control approach.

Scientific Cooperations

Internal
S. Cherednichenko, Group Inverse Problems
Dr. B. Vexler, Group Optimization and Optimal Control
Dr. R. Griesse, Group Optimization and Optimal Control

External
Dr. C. Meyer, Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
I. Yousept, TU Berlin, Department of Mathematics

Participation at Conferences, Scientific Visits and Talk

Conferences
07/03 Spring school and Workshop: Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen, Linz
07/04 Numerical Analysis Day Vienna
07/07 IFIP Conference, Cracow
07/09 FEM-Symposium Chemnitz
07/09 Chemnitz Symposium on Inverse Problems

Invited Talks
07/06/05. Bundeswehruniversität München, Regularization of a state constrained optimal control problem with boundary control -A virtual control concept-

Scientific Talks
07/04/26 Numerical Analysis Day Vienna, Regularization of a state constrained optimal control problem with boundary control -A virtual control concept-
07/07/26 IFIP Conference Cracow, A virtual control concept for state constrained optimal control problems
07/09/27 Chemnitz Symposium on Inverse Problems 2007, On the regularization error of a state constrained Neumann optimal control problem - A virtual control concept -

Scientific Visit
07/05 Scientific visit at University of Duisburg-Essen

Publications 2007

1. K. Krumbiegel, A. Rösch, A virtual control concept for state constrained optimal control problems, accepted for publication in Computational Optimization and Applications

2. K. Krumbiegel, A. Rösch, A new stopping criterion for iterative solvers for control constrained optimal control problems, submitted to SIAM Journal on Scientific Computing

3. K. Krumbiegel, A. Rösch, On the regularization error of state constrained Neumann control problems, submitted to Control and Cybernetics

Nataliya Metla advised by Prof. Arnd Rösch and Dr. Roland Griesse

Scientific Achievements 2007

In my research I investigated nonlinear optimal control problems with pointwise mixed control-state constraints and additional control constrains within the framework of the research project P18056-N12 funded by FWF.
Lipschitz stability and sensitivity of optimal solutions with respect to perturbations for semilinear elliptic problems were investigated. A convergence result for the SQP method in case of linear mixed constraints for elliptic problems was obtained and verified by numerical tests, and a publication has been submitted. I am currently investigating semilinear elliptic optimal control problems with nonlinear mixed control-state constraints given on the boundary.

Scientific Cooperations

Internal
Dr. Griesse (Group "Optimization and Optimal Control")

External
Prof. Dr. Rösch (University Duisburg-Essen, Germany)
MSc. Cherednichenko (University Duisburg-Essen, Germany)
DI Krumbiegel (University Duisburg-Essen, Germany)

Participation at Conferences, Scientific Visits and Talk

Conferences and Scientific Visits
- Spring School and Workshop „Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen" (March 5-9th, Linz, Austria)
- Jahrestagung der Deutschen Mathematiker-Vereinigung (March 25-30th, Berlin, Germany)
- 3. Austrian Numerical Analysis Day (April 26-27th, Vienna, Austria)
- 23rd IFIP TC 7 Conference on System Modelling and Optimization (July 23-27th, Cracow, Poland)
- Visit to Duisburg-Essen University to work on current article with Prof. Dr. Arnd Rösch and Dr. Roland Griesse (November 12-18th, Duisburg, Germany)
- Lipschitz Lectures 2007 (November 26th - December 11th, Bonn, Germany)

Scientific Talks
- "Convergence of SQP method for nonlinear elliptic problems with mixed constraints" (March 28th 2007, Berlin, Germany)
- "Approximation and regularization of optimization problems goverment by partial differential equations" (March 29th 2007, RICAM Scientific Board Meeting, Linz, Austria)
- "Convergence of SQP method for nonlinear elliptic problems with mixed constraints" (April 26th 2007, 3rd Austrian Numerical Analysis Day, Vienna, Germany)
- "Convergence of SQP method for nonlinear elliptic problems with mixed constraints" (July 24th 2007, 23rd IFIP TC 7 Conference on System Modelling and Optimization, Cracow, Poland)
- "SQP-Verfahren für nichtlineare elliptische Optimalsteuerungsprobleme mit gemischten Beschränkungen" (November 14th 2007, Duisburg, Germany)

Publications 2007

Submitted
R. Griesse, N. Metla and A. Rösch, "Local quadratic convergence of SQP for elliptic optimal control problems with mixed control-state constraints" (submitted)

Kattrin Arning advised by Prof. Heinz W. Engl

Kattrin Arning started to work as a doctoral student at the Johann Radon Institute for Computational and Applied Mathematics (RICAM) in the middle of September in 2006 and continued her work in the PhD Program in 2007.

PhD Program

The FWF doctoral college "Molecular Bioanalytics" (MoBA) is an interdisciplinary graduate research program involving the Institutes of Biophysics, Analytical Chemistry, Applied Physics, Organic Chemistry and Theoretical Physics from the Johannes-Kepler-University Linz, the RICAM and the Upper Austrian Research. In the course of this program Ms. Arning works in particular on the simulation of ion channels and on inverse problems related to them. The behaviour of ions passing through the channels can be described by a system of nonlinear partial differential equations. To simplify the numerical treatment and the computational effort a linearized surrogate model has been derived to describe the basic current-voltage relationships that occur in ion channels. This surrogate model is in turn used to identify individual channel parameters. Ways to include the opening and closing of the channel, a behaviour called gating, into the PDE model are currently considered.
Since the inner part of an ion channel is a very narrow region, Ms. Arning started to investigate a discrete particle-based approach to model the ion movement across the channel. This approach is based on energy considerations inside the filter, where it needs to be taken into account that the passing ions highly alter the potential landcape.

Workshops, Conferences and Scientific Talks

Workshops & Conferences
- 9. Annual Linz Winter Workshop "Advances in Single-Molecule Research for Biology & Nanoscience", 02.-05.02.2007 at the Johannes Kepler University, Linz
- Satellite Symposium of PhD Programs: Molecular Enzymology & Molecular Bioanalytics, 06.02.2007, Linz
- International Congress on Industrial and Applied Mathematics, 16.-20.07.2007 in Zurich, Switzerland
- 17th Jyväskylä Summer School 12.-25.08.2007, Finland
- Summer School "Molecular Bioanalytics" in Saalbach-Hinterglemm, 16.-18.09.2007
- Workshop on Ion Channels, Special Semester on Quantitative Biology analyzed by Mathematical Methods, RICAM, Linz

Scientific Talks
- Poster presentation at the 9. Annual Linz Winter Workshop "Advances in Single-Molecule Research for Biology & Nanoscience"
- "Simulation of Ion Channels" (group seminar RICAM, May)
- Conference talk at the ICIAM, June, Zurich, Switzerland
- Talk at the Summer School "Molecular Bioanalytics"
- Talk at the Ion Channel workshop in the Special Semester

Scientific Cooperations

Internal
Dr. Lin He
DI Marie-Therese Wolfram

External
Prof. Martin Burger (University of Münster)
Prof. Robert S. Eisenberg (Rush University Medical Center, Chicago)

Dr. Lin He

Introduction

Dr. Lin he received her Ph.D. degree from the department of mathematics in University of California, Los Angeles in June 2006. And since July 2006 she is employed in the group of Inverse Problem of RICAM by project F1308. Her main topics of research are inverse problems with PDEs, image processing and computational tomography, and level set methods and its applications.

Scientific Achievements 2007

Since Jan 2007, Dr. He has carried out research in several directions:

Inverse Problems related with Ion Transport
Ion channels are proteins with a hole down their middle that allow ions move across otherwise impermeable cell membranes, thereby controlling many important physiological functions, such as conducting electrical signals down nerves and initiating muscle contraction. Connecting two baths of fixed ionic concentrations, a single ion channel is immersed in hard-sphere fluid with charged ions. Gillespie et al simplified the movement of the ions to one-dimensional and describe the particle transport as friction-limited drift-diffusion (Poisson-Nernst-Planck) with all excess chemical potentials given by the density functional theory of Rosenfeld. Based on this work, Burger et al. investigated inverse problems related with ion channels. They tried to determine one of the structural features of a channel, its permanent charge induced by the confined species inside the channel from measurements of output currents depending on different input voltages. They also tried to design channels with desirable properties such as particular selectivity properties by using the methods of inverse problems. However, much work still needs to be done. Due to the high computational effort to solve the PNP equation, we derive a reduced surrogate model for characterizing the current-voltage (i.e., the conductance) relationship. This surrogate model is used to identify some basic channel properties like the permanent charge and the radius of the channel. For the reconstruction of both, our numerical results show accurate results even under the presence of noise in the current data. We also observe that the higher the permanent charge is the higher the conductance is and the longer the radius of the channel is the higher the conductance is. This work has been presented by Dipl. -Math. techn. Kattrin Arning in ICIAM 2007, Zurich.

Reconstruction of the Shape and Surface Impedance from Acoustic Scattering Data by Level Set Methods
The inverse scattering problem is to identify some properties of an obstacle from the information contained in the scattered wave for given incident waves. Introduced by Santosa to the inverse scattering field, the level set method has made a strong contribution to this field, see a review paper by Dorn and Lesselier. In our recent work, from the far field of the scattered wave we reconstruct the shape of the obstacle with the impedance boundary condition, where the impedance function is also unknown. This is done by alternatively minimizing the objective functional, the distance between the

given far field information and the far field of the scattered wave based on the computed shape and the impedance function. To update the shape of the object (represented by the zero level set) and the impedance function, we use the gradient-descent method, where we need to calculate the descent direction, i.e., the shape derivative. The shape derivative involves solving the original Helmholtz equation and the corresponding adjoint equation. To solve the original equation and the adjoint equation, we calculate the boundary integral which requires an explicit expression of the boundary of the object, i.e., the zero level set. This is the difficult part of the work and it does not take the advantage of level set methods, which is no need to track the curve. Nevertheless, by using the boundary integral representation (1D), we save the computation time. Furthermore, the preliminary results show accurate reconstruction of the shape of the obstacle and the impedance function even for a non-convex shape obstacle and non-constant impedance function. We also obtain good reconstruction of the shape of the obstacle and the impedance function from noisy data.

Topological Derivatives on Image Segmentation
This work has been revised and published, see **Publications 2007**.

Image Inpainting using the H_1 norm of the TV Regularization
Image inpainting is the filling in of damaged or missing regions of an image using information from surrounding areas. Relying on a principle that variational denoising, segmentation and inpainting models all have an underlying notion of what constitutes an image, Chan and Shen used the total variation based denoising model for inpainting. This model also includes a fidelity term that ensures the solutions close to the given image in non-inpainting regions. This model can successfully propagate sharp edges into the damaged domain. However, since the use of the TV regularization puts a penalty on the length of edges, this inpainting model cannot connect contours across very large distances. A different approach to inpainting, based on nonlinear PDE, was proposed by Bertalmio et al.. They propagate the information of an image smoothness estimator, simply defined as the Laplacian of the image, in the direction of isophotes given by the contour of constant grayscale image intensity. In a subsequent work with Bertozzi, they realized that the above nonlinear PDE has intimate connections with two dimensional fluid dynamics through the Naiver-Stokes equation. Recently Bertozzi et al. proposed a two-step Cahn-Hilliard model for inpainting of binary images, which is done by choosing two different values of the measure parameter ε according to different initial conditions. They have shown the existence and uniqueness of a weak solution of the evolution equation. However the existence of a solution of the stationary equation and the convergence of the evolution equation to a stationary state remain unaddressed. Therefore we addressed these issues in our work. Furthermore, we let the measure parameter ε goes to zero. As a direct result, the two-step procedure is not needed. Instead, we obtain a new equation, which is the summation of the gradient flow of the H^{-1} norm of the TV regularization and the gradient flow of the L^2 norm of the fidelity term. By using the H^{-1} norm of the TV regularization, there is no penalty on the length of the edges. Therefore, contours can be connected even across large distances. Similar theoretical results of this BV H^{-1} model can be proved and our numerical experiments show the robustness in terms of the initial condition. Most important of all, with the use of TV regularization, we have extended from inpainting of binary images by the Cahn-Hillard model to inpainting of grey-value images by our model.

Convergence rates of a Bregman iterative regularization method for image denoising
This work has been revised and published, see **Publications 2007**.

Scientific Cooperation 2007

Internal

- on “Reconstruction of the Shape and Surface Impedance from Acoustic Scattering Data by Level Set Methods”, with Dr. Mourad Sini (Inverse Problems group/RICAM) and Dr. Stefan Kindermann (Inverse Problems group/RICAM).

External
- on "Inverse Problems related with Ion Transport", with Dipl. -Math. techn. Kattarin Arning (Inverse Problems group/RICAM), Prof. Dr. Martin Burger (Westfaelische Wilhelms Universitaet Muenster, Germany), Prof. Robert Eisenberg (Rush University, U.S.A), Prof. Dr. Heinz Engl (Inverse Problems group/RICAM).
- On "Image Inpainting using the *H_1* norm of the TV Regularization" with Prof. Andrea Bertozzi (UCLA, U.S.A) Prof. Dr. Martin Burger (Westfaelische Wilhelms Universitaet Muenster, Germany), Prof. Dr. Peter Markovich (Vienna University) and DI. Carola Schoenlieb (Vienna University).
- On "Convergence rates of a Bregman iterative regularization method for image denoising" with Prof. Dr. Martin Burger (Westfaelische Wilhelms Universitaet Muenster, Germany) and Dr. Elena Resmerita (Inverse Problems group/ RICAM)
- On "Topological Derivatives on Image Segmentation" with Prof. Stanely Osher (UCLA, U.S.A)

Participation at Conferences, Scientific Visits and Talks 2007

Conferences
- Lin He, Solving the Chan-Vese Model by a Multiphase Level Set Algorithm Based on the Topological Derivative, The 6th International Congress of Industry and Applied Mathematics (ICIAM), Zurich, Switzerland, July 2007.
- Lin He, MR Image Reconstruction by Using the Iterative Refinement Method and Nonlinear Inverse Scale Space Methods, The 6th International Congress of Industry and Applied Mathematics (ICIAM), Zurich, Switzerland, July 2007.
- Lin He, Solving the Chan-Vese Model by a Multiphase Level Set Algorithm Based on the Topological Derivative, 1st International Conference on Scale Space Variational Methods in Computer Vision, Ischia, Italy, May 2007.

Scientific Talks
- Lin He, MR Image Reconstruction by Using the Iterative Refinement Method and Nonlinear Inverse Scale Space Methods, Workshop on Bioimaging II/PDE, RICAM, Linz, Austria, Nov 2007.
- Lin He, Reconstruction of the Shape and the Surface Impedance from Acoustic Scattering Data by Level Set Methods, Department of Mathematics, University of California in Los Angeles, Los Angeles, U.S.A., Sept 2007.
- Lin He, Inverse Problems related with Computational Tomography and Image Segmentation, Department of Computational and Applied Mathematics, Westfaelische Wilhelms Universitaet Muenster, Muenster, Germany, Apr 2007.
- Lin He, Inverse Problems related with Computational Tomography and Image Segmentation, Department of Mathematics and Scientific Computing, University of Graz, Graz, Austria, Apr 2007.
- Lin He, Inpainting with Higher Order Energy, Annual meeting of SFB1308 Project, Austria Academy of Sciences, Strobl, Austria, Apr 2007.
- Lin He and Elena Resmerita, Error estimations for Bregman iterations, Seminar talks, RICAM, Linz, Austria, Mar 2007.
- Lin He, Solving the Chan-Vese Model by a Multiphase Level Set Algorithm Based on the Topological Derivative, Trends in Mathematical Imaging and Surface Processing, Forschungsinstitut Oberwolfach, Germany, Jan 2007.
- Lin He, Inverse Problems related with Computational Tomography and Image Segmentation, Department of Mathematics, University of California, Davis, U.S.A, Jan 2007.

Publications 2007

Published

- Martin Burger, Elena Resmerita, and Lin He. Error estimation for bregman iterations and inverse scale space methods in image restoration. In O. Scherzer B. Juettler, H. Pottmann, editor, Special Issue on Industrial Geometry, volume 81, pages 109-135. Springer Wien, Novermber 2007.
- Lin He and Stanley Osher. Solving the Chan-Vese model by a multiphase level set algorithm based on the topological derivative. In Scale Space Variational Methods in Computer Vision, Lecture Notes in Computer Science, pages 777-788. Springer Verlag, 2007.
- Lin He, Chiu-Yen Kao, and Stanley Osher. Incorporating topological derivatives into shape derivatives based level set methods. Journal of Computational Physics, 225(1): 891-909, 2007.

Submitted:

- Lin He, Stefan Kindermann, and Mourad Sini. Reconstruction of shapes and impedance functions using few farfield measurements. Submitted to Journal of Computational Physics, 2007.
- Kattrin Arning, Martin Burger, Heinz Engl, Robert Eisenberg, and Lin He. Inverse problems related with ion channels. Submitted to Proceedings in Applied Mathematics and Mechanics, 2007.
- Martin Burger, Lin He, Peter Markowich, and Carola Schoenlieb. A generalization of Cahn-Hilliard inpainting for grayvalue images. Submitted to Proceedings in Applied Mathematics and Mechanics, 2007.
- Lin He, Ti-Chiun Chang, Stanley Osher, Tong Fang, and Peter Speier. MR Image Reconstruction from Undersampled Data by Using the Iterative Refinement Procedure. Submitted to Proceedings in Applie Mathematics and Mechanics, 2007.
- Lin He and Stanley Osher. A Fast Multiphase Level Set Algorithm for Solving the Chan-Vese Model. Submitted to Proceedings in Applied Mathematics and Mechanics, 2007.
- Andrea Bertozzi, Martin Burger, Lin He, Peter Markowich, and Carola Schoenlieb. Inpainting with higher order energies. Submitted to Congresso Nacional de Matematica Aplicada e Computacional, 2007.

Scientific plans for 2008

Dr. He left to UCLA the end of December 2007.

Dr. Marcin Janicki

Funded via an FWF Lise Meitner Fellowship

Scientific Achievements 09-12/2007

Retrieving local, instantaneous values of the heat transfer coefficient:
When analyzing electronic circuits, it is necessary to perform transient thermal simulations of the processes which are by their nature nonlinear. The main source of nonlinearity is the variable heat transfer rate at the outer surfaces of a structure. This phenomenon is modelled in the heat equation by the heat transfer coefficient in the Robin boundary conditions. The value of this coefficient depends on many factors such as the absolute temperature, the surface-ambient temperature difference, cooling fluid velocity, etc. Taking into account the fact that the temperature differences in electronic circuits typically exceed 100 ˚C, significant spatial and temporal variations in the coefficient value occur. Thus, for accurate dynamic thermal simulations it is necessary to identify the actual, local coefficient values.
The dependence of the heat transfer coefficient on temperature was estimated by the coupling of the forward solver based on Green's functions with the inverse solver using Landweber iterations. Based

on the electrical and infrared measurements of a real hybrid circuit, the values of the heat transfer coefficient were successfully estimated both for free convection and forced water cooling conditions. The retrieved dependence of the heat transfer coefficient on temperature agrees with the theoretical expectations. Owing to the adopted approach it was possible to improve significantly the thermal simulation accuracy.

Grants

FWF – Project M984-N18
Title: Inverse Termal Problems in Electronics
Project Leader: Dr. M. Janicki
Project start: September 2007

Scientific Cooperations

Internal
Dr. Stefan Kindermann

External
Prof. Gilbert De Mey, University of Ghent, Belgium
Prof. Andrzej Napieralski, Technical University of Lodz, Poland

Participation at Conferences, Scientific Visits and Talk

Scientific Talks
Inverse thermal problems in electronic, RICAM Group Seminar, Linz, Austria, November 8, 2007

Publications 2008

Accepted
[1] M. Janicki, S. Kindermann, P. Pietrzak, B. Vermeersch, J. Banaszczyk, G. DeMey, A. Napieralski, Determining Thermal Simulation Data From Transient Measurements, accepted for 24th Conference on Semiconductor Thermal Measurement, Modelling, and Management - SEMI-THERM March 16-20, 2008, San Jose, CA, USA
[2] M. Janicki, S. Kindermann, P. Pietrzak, M. Kamiński and A. Napieralski, Estimation of local temperature dependent heat transfer coefficient for dynamic thermal analysis of electronic circuits, accepted for 6th International Conference on Inverse Problems in Engineering: Theory and Practice, June 15-19, 2008, Dourdan (Paris), France

Dr. James Lu

Scientific Achievements 2007

Research has continued on formulating and solving inverse problems arising from the field of systems biology. Work in this area may be broadly divided into two classes: 1) reconstruction of gene networks from time-series data; 2) inferring how qualitative properties of networks arise from nonlinear biochemical mechanisms and network topology.

Extensions to the SBML ODE Solver Library (SOSLib) have been carried out to allow for usage within parameter identification algorithms. In particular, API for solving forward and adjoint sensitivity equations have been developed. SOSLib has been used in conjunction with the interior

point optimization library IPOPT and applied to a suite of benchmark problems. Parameter identification has been successfully performed using a sparsity-promoting l_p penalty as the regularization term. Currently in progress is the concatenation of scatter search (as a globalization strategy) with local, gradient-based method.

Motivated by biological applications, effort are under way to extend algorithms for inverse eigenvalue analysis that have been developed for inferring biochemical mechanisms that give can rise to desired qualitative behavior. For instance, in many cases one is not only looking for gene systems exhibiting behavior such as bistability or oscillation, but in fact one would additionally like to control the types of qualitative behavior: these may include specifying the set of genes being up- or down-regulated as a bifurcation parameter varies, or obtaining a particular pattern of oscillations such as requiring a phase relationship between the species. These additional conditions require to solve inverse eigenvalue problems with partially prescribed eigenvectors. There are also algorithmic extensions arising from the particular properties of biological networks. For instance, since biological networks are typically sparse, the non-zero patterns should be respected in the lift-and-project algorithm. Correspondingly, in the matrix inverse singular value problems that need to solved, one would like to place the additional condition that the zero structure of lifting matrices should be maintained. Work also continues in applying inverse dynamical analysis to problems posed by our biology-partners at the University of Vienna. In particular, a GATA transcription factor model is being analyzed to investigate mutations that would relieve hypersensitivity arising from a gene duplication event, as well as mutations that could induce oscillations following a scenario involving gene duplication and the loss of trans-activating domain.

Scientific Cooperations

Internal
Prof. Heinz W. Engl, Stefan Müller, Philipp Kügler

External
Prof. Peter Schuster, Rainer Machne, Lukas Endler, Christoph Flamm, Theoretical Biochemistry Group, University of Vienna.

Douglas Murray, Keio University, Japan.

Participation at Conferences, Scientific Visits and Talk

Conferences

- SBML Hackathon, June 2007, Newcastle, UK.
- AMS von Neumann Symposium on Sparse Representation and High-Dimensional Geometry, July 2007, Snowbird, Utah, USA.
- 6th International Congress on Industrial and Applied Mathematics, July 2007, Zurich, Switzerland.
- International Conference on Systems Biology, October 2007, Long Beach, USA.
- Systems Biology Workshop, RICAM Special Semester on Quantitative Biology analyzed by Mathematical Methods, November 2007, Linz, Austria.

Publications 2007

Appeared
J. Lu, H. W. Engl, R. Machne', P. Schuster: Inverse bifurcation analysis of a model for the mammalian G1/S regulatory module. Proceedings for Bioinformatics in Research and Development '07, Lecture Notes in Bioinformatics, Springer-Verlag, 2007.

Submitted
J. Lu, S. Mueller, R. Machne', C. Flamm: Extensions to SOSlib: forward and adjoint sensitivity analysis capabilities.

Dr. Stefan Mueller

Scientific Achievements 2007

Stefan Mueller continued his work on the dynamics of cellular networks using both forward and inverse methods. His studies included (i) parameter identification in biochemical reaction networks, (ii) bifurcation analysis in gene regulatory networks.

Parameter identification:
To identify unknown parameters of biochemical reaction networks from experimental data, Stefan Mueller implemented an interface between the existing *SBML ODE Solver Library (SOSlib)* and the local optimizer *IpOpt*, which allows a convenient problem specification. A parameter identification problem consists of an *SBML* model (containing a reaction network or an ODE model), a list of parameters to be identified with corresponding lower/upper bounds and priors, an objective function to be minimized, and a list of data files. Both kinetic parameters and initial conditions of chemical species can be identified and logarithmic scaling in the search space can be used; the data can be given as continuous-time measurements or experimental values at discrete time-points. The objective function can be constructed automatically from the data files: in this case it consists of an L_2 error term (in all chemical species for which data is available) and a l_p penalty term (in all parameters to be identified), where p=2 is the standard case and $0<p<1$ corresponds to a sparsity constraint. In the general case, an arbitrary objective function (an arbitrary observation operator) can be specified and its consistency with the data files is checked automatically. A penalty term in the objective function corresponds to a regularization of the identification problem. Regularization serves to stabilize the solution with respect to data noise. After the problem specification, the evaluation of the objective function and the gradient computation can be performed using forward and adjoint capabilities of *SOSlib*. (To deal with all the cases mentioned above, SOSlib had to be modified and extended.) Finally, the identification problem is solved with the local optimizer *IpOpt*, a software package implementing an interior point method. The resulting parameter identification package has been tested on a number of biological and chemical systems.

Bifurcation analysis:
To investigate bifurcations in simple gene regulatory networks, Stefan Mueller applied methods from algebra and symbolic computation, which allow a complete stability analysis of equilibrium points. The work is motivated by the study of evolutionary scenarios for a GATA transcription factor network. The case of a single (auto-activating) gene is modelled by a 4 dimensional ODE system with 3 signals and 19 rate and equilibrium constants. It can be shown that the well-known saddle-node bifurcation depends on only 2 (combined) parameters, and that no Hopf bifurcations can occur. After gene duplication (and after some mutation events) new, more complicated systems arise. To apply the algebraic methods mentioned below, some simplifications and symmetry assumptions have to be made. The symbolic computations are complemented by numerical analysis done by James Lu using Inverse Eigenvalue Analysis.
Together with Georg Regensburger (from the Symbolic Computation group), Stefan Mueller analyzed 2 and 3 gene systems with an arbitrary activation function. For this purpose, the well-known Routh-Hurwitz criterion was adapted to detect saddle-node and Hopf bifurcations. The Hurwitz determinants appearing in the analysis are computed generically (either explicitly or by a recursion) and are then simplified using the equations for the equilibria of the ODE system. More precisely, the Jacobian is reduced modulo the ideal generated by the equilibrium equations using a Gröbner basis. Finally, the positivity of the Hurwitz determinants of the reduced Jacobian is studied. The symbolic analysis was

carried out using the software packages *Mathematica* and *Maple*.

Scientific Cooperations

Internal

Cooperation with Prof. Heinz Engl and Dr. Philipp Kuegler on parameter identification in biochemical systems, and with Dr. James Lu on bifurcation analysis in gene regulatory networks

Cooperation with Dr. Georg Regensburger (Symbolic Computation Group) on algebraic and symbolic methods in bifurcation analysis

External

Cooperation with Mag. Rainer Machne (Institute for Theoretical Chemistry, University of Vienna) on evolutionary scenarios for gene regulatory networks

Participation at Conferences, Scientific Visits and Talks

Tutorial: *Inverse methodologies for systems biology: SOSlib, MathSBML and Matlab extensions*, The Eighth International Conference on Systems Biology, Long Beach, 2007

Poster Presentation: *SBML ODE Solver Library: Extensions for Inverse Analysis*, The Eighth International Conference on Systems Biology, Long Beach, 2007

Poster Presentation: *The evolution of the bifurcation phenotype: phylogenetic and dynamical analysis of fungal GATA networks*, The Eighth International Conference on Systems Biology, Long Beach, 2007

Talk: *Parameter identification in systems biology: solving inverse problems using regularization,* Special Semester on Quantitative Biology analyzed by Mathematical Methods, Workshop on Systems Biology, Linz, 2007

Publications

Appeared

C. Flamm, L. Endler, S. Müller, S. Widder, P. Schuster, *A minimal and self-consistent in silico cell model based on macromolecular interactions*, Phil Trans R Soc Lond B Biol Sci 362 (1486), 1831-1839

Dr. Hanna Katriina Pikkarainen

Scientific Achievements 2007

Dynamical inverse problems:
Dr. Pikkarainen has worked on the analysis of nonstationary linear inverse problems as state estimation problems. Especially the effect of approximation errors, e.g., discretization errors, in dynamical inverse problems has been in the interest of Dr. Pikkarainen. She has presented a finite-dimensional filtering method taking into account discretization errors in a finite-dimensional state estimation system representing an infinite-dimensional nonstationary inverse problem. Numerical implementation of the filtering method was done in collaboration with Ph. Lic. Janne Huttunen

(University of Kuopio, Finland) in a one-dimensional model case. The results and the effectiveness of the method were presented in article [1].

Dr. Pikkarainen has examined in collaboration with Dr. Jarmo Malinen (Helsinki University of Technology, Finland) Kalman filter type of solutions of infinite-dimensional linear nonstationary inverse problems. A publication is in preparation.

Convergence results for the Bayesian inversion theory:
Recently, the metrics of Ky Fan and Prokhorov were introduced as a tool for studying convergence of regularization methods for stochastic ill-posed problems. Dr. Pikkarainen has shown together with Dr. Andreas Hofinger that the Bayesian approach to linear inverse problems can be examined in the new framework as well. They considered the finite-dimensional case where the measurements are disturbed by an additive normal noise and the prior distribution is normal. Convergence and convergence rate results for the posterior distribution in the Bayesian approach were obtained when the covariance matrices are proportional to the identity matrix. The results were published in article [2]. Dr. Pikkarainen has generalized in collaboration with Dr. Andreas Hofinger the previous results for the case of arbitrary positive definite symmetric covariance matrices. The generalization and a comparison with the frequentist approach to linear inverse problems were presented in paper [3].

Dr. Pikkarainen has studied in collaboration with Prof. Dr. Andreas Neubauer (Johannes Kepler Universität Linz) order optimal convergence rate results for posterior distribution in the Bayesian inversion theory in finite dimensions. Moreover, they have proved that order optimal rates can be obtained for weighted Bayesian solutions when the dimension of an inverse problem goes to infinity. The results were presented in article [4].

Dr. Pikkarainen supervised together with Dr. Stefan Kindermann (Johannes Kepler Universität Linz) the Master's thesis of Rajesh Kumar (Johannes Kepler Universität Linz) with title *Error estimates and their numerical verifications for the Bayesian approach to inverse problems*. The thesis was a numerical verification of the convergence results for the posterior distribution that Dr. Pikkarainen has obtained with Dr. Andreas Hofinger in the Bayesian inversion theory.

Dr. Pikkarainen has examined together with Prof. Dr. Thorsten Hohage (Georg-August-Universität Göttingen, Germany) the convergence of the conditional expectation in the infinite-dimensional Bayesian inversion theory. A publication is in preparation.

Bayesian approach to nonlinear inverse problems in symbolic computation:
Dr. Pikkarainen has studied in collaboration with Prof. Dr. Josef Schicho some nonlinear inverse problems related to symbolic computation using the Bayesian inversion theory. A paper with the tentative title *A Bayesian model for root computation* is in preparation.

Scientific Cooperations

Internal
Prof. Dr. Josef Schicho

External
Prof. Dr. Thorsten Hohage, Georg-August-Universität Göttingen, Germany
Ph. Lic. Janne Huttunen, University of Kuopio, Finland
Dr. Stefan Kindermann, Johannes Kepler Universität Linz, Austria
Dr. Jarmo Malinen, Helsinki University of Technology, Finland
Prof. Dr. Andreas Neubauer, Johannes Kepler Universität Linz, Austria

Participation at Conferences, Scientific Visits and Talk

Conferences
- Conference on Applied Inverse Problems 2007, Vancouver, Canada, June 25-29, 2007
- 6th International Congress on Industrial and Applied Mathematics (ICIAM 2007), Zürich, Switzerland, July 16-20, 2007

Activities as a Mentor/Organizer
- mentored a RICAM - ICIAM grant winner Mihaela Pricop, Georg-August-Universität Göttingen, Germany, July 2-13, 2007.
- co-organization of the minisymposium Statistical methods in inverse problems at the 6th International Congress on Industrial and Applied Mathematics (ICIAM 2007), Zürich, Switzerland, July 16-20, 2007 (together with Prof. Dr. Thorsten Hohage, Georg-August-Universität Göttingen, Germany)
- a member of the scientific committee of the Special Semester on Stochastics with Emphasis on Finance organized at RICAM in September – December 2008

Scientific Visits
- Institut für Numerische und Angewandte Mathematik, Georg-August-Universität Göttingen, Germany, March 19-23, 2007 (Prof. Dr. Thorsten Hohage)

Scientific Talks
- Convergence rates for linear inverse problems in the presence of an additive normal noise, Georg-August-Universität Göttingen, Germany, March 21, 2007
- Convergence rates for the Bayesian approach to linear inverse problems, SFB Status Seminar, Strobl, Austria, April 12, 2007
- *State estimation approach to nonstationary inverse problems*, Conference on Applied Inverse Problems 2007, Vancouver, Canada, June 28, 2007
- *Convergence rates for the Bayesian approach to linear inverse problems*, 6th International Congress on Industrial and Applied Mathematics (ICIAM 2007), Zürich, Switzerland, July 18, 2007

Publications 2007

Appeared

[1] J. M. J. Huttunen and H. K. Pikkarainen. Discretization error in dynamical inverse problems: one-dimensional model case. *Journal of Inverse and Ill-Posed Problems*, 15(4), pp. 365-386, 2007.

[2] A. Hofinger and H. K. Pikkarainen. Convergence rate for the Bayesian approach to linear inverse problems.
Inverse Problems, 23(6), pp. 2469-2484, 2007.

Submitted

[3] A. Hofinger and H. K. Pikkarainen. Convergence rates for linear inverse problems in the presence of an additive normal noise. submitted for publication, 2007.

[4] A. Neubauer and H. K. Pikkarainen. Convergence results for the Bayesian inversion theory. submitted for publication, 2007.

Dr. Eva Sincich

Work before joining Ricam

I received my PhD from SISSA (International School of Advanced Studies), Trieste, Italy in October 2005. From November 2005 to October 2006 I held a post doc position at Inria of Sophia Antipolis, France.

The main topics of my PhD thesis are related to the stability and the reconstruction of coefficients in boundary conditions. More precisely,
1. Stability estimate for a nonlinear term which models the phenomenon of corrosion in metals.
2. Reconstruction procedure for the (above mentioned) nonlinear term.
3. Stability estimate for an impedance coefficient in an inverse scattering problem.

During my post doctoral stay at Inria (France) I mainly worked on inverse boundary problems for the Beltrami equation on a 2-D doubly connected domain. This may find applications in the study of plasma confinement for thermonuclear fusion in a Tokamak. In the most recent Tokamaks, like for instance ITER in Cadarache (France), an interesting feature of the level curves of the poloidal flux is the occurrence of a cusp (a saddle point of the poloidal flux, called an X point), and it is desirable to shape the plasma according to a level line passing through this X point for physical reasons relating to the efficiency of the energy transfer.

Scientific Achievements in 2007

1. Lipschitz stability for the inverse Robin problem.
This work concerns the determination of a linear boundary term (the so called Robin coefficient) that models the corrosion appearance in metals on an inaccessible portion of the boundary from electrostatic measurements performed on the accessible one.
I provided a Lipschitz stability estimate for the inverse Robin problem under the further a priori assumption of a piecewise constant Robin coefficient. I also proved, developing a quite recent method introduced by N.Mandache, that the Lipschitz constant of the above mentioned estimate behaves exponentially with respect to the number of portions considered.

2. Reconstruction for a nonlinear corrosion problem.
In joint work with P. Kügler, we are concerned with a more accurate model of corrosion appearance which postulates a nonlinear relationship between the normal current density and the boundary voltage. We propose an approach based on the output least squares formulation with Tikhonov regularization.
In cooperation with H. Cao and S. Pereverzyev we consider the numerical solution of the above mentioned inverse problem which can be naturally linearized. We describe and test a regularized reconstruction algorithm based on regularization by discretization, where the discretization level is chosen in data driven way.

3. Stability for the determination of a sound soft obstacle.
In collaboration with M. Sini, we studied an inverse scattering problem arising in target identification. The purpose is to provide a stability result for a sound soft obstacle, so that the total acoustic field satisfies a homogeneous Dirichlet condition on the boundary of the obstacle, in terms of the measurements of the far field pattern. Actually, we are interested in the local stability, i.e., we impose the further a priori assumption that the unknown obstacle is sufficiently close to a given one. This further hypothesis allows us to determine the obstacle by (only) one measurement of the far field pattern, namely at fixed energy and at a fixed direction.
The main tools used to deal with the stability issue rely on quantitative estimates of unique continuation. Indeed, we are interested in a quantitative stability analysis, not only in a qualitative one:

we provide an explicit evaluation of the modulus of continuity of the dependence on the unknown obstacle by the scattering data. The local uniqueness result for such a problem has been previously studied by P. Stefanov and G. Uhlmann.

Scientific Cooperations

Internal
Dr. Hui Cao
Dr. Philipp Kügler
Prof. Sergei Pereverzyev
Dr. Mourad Sini

External
Prof. Giovanni Alessandrini (University of Trieste, Italy)
Laurent Baratchart ("Directeur de recherché" , Inria, France)
Dr. Romina Gaburro (Post doc, University of Limerick)
Juliette Leblond ("Directeur de recherché" , Inria, France)
Dr. Luca Rondi (University of Trieste, Italy)

Participation at Conferences, Scientific Visits and Talk

Scientific Visits
Three days visit at Inria of Sophia Antipolis (France) from the 13th to the 15th of June.

Conferences
Talk at the AIP Conference in Vancouver, Canada, in June 2007.
Talk at the 6th ISAAC Congress, Ankara, Turkey, in August 2007.

Seminar Talks
RICAM, Linz.
SFB-Statusseminar, Strobl (Austria).
Inria, Sophia Antipolis (France).
University of Udine (Italy).

Publications 2007

[1]G. Alessandrini, E. Sincich, Solving elliptic Cauchy problems and the identification of nonlinear corrosion. J. Comput.Appl. Math. 198 (2007), no.2, 307-320.
[2]E. Sincich, Lipschitz stability for the inverse Robin problem, Inverse Problems, 23 (2007), 1311-1326.

Submitted 2007
[3]E. Sincich, M. Sini, Local stability for soft obstacle by a single measurement, RICAM-Report No. 2007-23
[4]H. Cao, S. Pereverzev, E. Sincich, Natural linearization for corrosion identification.

Dr. Mourad Sini

Member of the Inverse Problems Group of RICAM since September 2006.

Achievements during the year 2007

I. Scientific Achievements

I. 1. Completion of previous work by revision of papers submitted in 2006 (see the report of 2006).

I. 2. Reconstruction of complex obstacles from far field measurements.

A. In previous papers we studied the inverse scattering problem from complex obstacles using the probing method. A few months ago, we submitted a paper, in collaboration with Prof. F. Cakoni, where we proved that the Linear Sampling Method can also be used to fully solve this problem. All the published papers using the Linear Sampling Method consider just the reconstruction of the shape and some estimates of the boundary terms.

B. In collaboration with J.J. Liu (who is our guest for the current special semester) and P. Krutitskii, we considered the crack problem regarding the forward and inverse scattering problem related to the Helmholtz equation. We are summarizing these works in two papers that we will submit very soon.

C. We made good progress in understanding the known proposed methods for the scattering problem for reconstructing interfaces. We believe that we can never recover interfaces with an arbitrary precision (and this is independent of the methods used!). Indeed, as a first conclusion, the sign of the *curvature* of the unknown obstacle makes it difficult to get good reconstruction. It perturbs the visibility from exterior measurements. In a recent work, we added ***complex*** valued surface impedance at the interface and remarked that it can be chosen to compensate the disadvantage of the curvature. This is exactly the coating effect used by engineers. However, this is just a **first order** of coating. Higher orders will be considered later. We will submit a written paper on this topic soon.

I. 3. Detection of polygons from few boundary measurements.
3.a The first work (jointly with Prof. R. Potthast) concerns reconstruction of the convex hull of 3D polygons from one far filed measurement for the full Maxwell system. We already submitted that paper.

3.b The other works are joint with Prof. N. Honda and Prof. G. Nakamura. This concerns the detection of polygons for some general second order elliptic equations. The polygon models the discontinuity of the coefficient of the lower order terms in the equations. The main point is to show the non-analytic extension of the total fields near the vertices. This work will be submitted soon. The second related work concerns the obstacle case where we estimate a finite number of incident waves needed to recover a polygonal obstacle for a general second order elliptic operator. This does not use any reflection argument as it is used in published work which requires the associated coefficients to be constant.

I. 4. Stability and reconstruction of obstacles from one measurement.
4.1 In collaboration with Dr. L. He and Dr. S. Kindermann, we studied the reconstruction of the shape of an obstacle from one measurement using the level set method. So far, we gave the partial results by coupling a level set method with the integral equation method. A first paper has been submitted.

We are now working on replacing the integral equation representation by finite element methods.

4.2 In collaboration with Dr. E. Sincich, we studied the stability estimate for this problem for the Dirichlet obstacle. This gives a stability version of the uniqueness result by Stephanov and Uhlmann. We submitted the obtained work for publication.

II. Supervision and teaching.

Supervision of two master theses defended on july 24th 2007:
II. 1: 'Inverse Problems in Transient Elastogaphy' by Mr. **Kho Sinatra Canggih.**
II. 2: 'Indentification of Hydraulic Conductivity in Groundwater Modeling' by **Vincent Ssemaganda.**

Giving a 4-hour-per-week course on the 'Mathematical Methods of Continuum Mechanics' in the spring semester of 2007.

Scientific Cooperations

Internal
Prof. S. Sergei Pereverzyev
Dr. Stefen Kindermann
Dr. Lin He
Dr. Eva Sincich

External
Prof. Gen Nakamura (Hokkaido University, Japan)
Prof. Roland Potthast (University of Reading, UK)
Prof. Antonino Morassi (University of Udine, Italy)
Prof. Jijun Liu (South east University, China)
Prof. J. K. Seo (Yonsei University, South Korea)
Prof. Fioralba Kakoni (University of Delaware, USA)
Prof. R. Kress (University of Gottingen, Germany)
Dr. Kenji Shirota (Ibaraki University, Japan)
Prof. Robert J. Renka (University of North Texas)
Prof. Pavel Krutitskii (Moscow M.V. Lomonosv State University)

Participation at Conferences, Scientific Visits and Talk

Scientific Visits
- Two weeks visit to Hokkaido University in Japan. January 2007.
- Two weeks visit to University of Provence, and University of Franche Comte, France. February-march 2007.
- One week visit to ENIT, Tunis, December 2007.

Conferences
- Talk at the **AIP** conference, Vancouver, Canada. June 2007.
- Talk at the **ICIAM** conference at Zurich. July 2007.
- Talk at the 8th Inter. Workshop. **MMSTBE**, Greece, September 2007.

Seminar Talks
- Univ. of Provence (one time), Univ. of Montpellier (one time) and Univ. of Franche Comte (two times) (France).
- RICAM and Strobl (Austria).
- ENIT (Tunis).

Publications during the 2007

Appeared

1. A. Morassi, G. Nakamura, K Shirota and M. Sini, A variational approach for the inverse dynamical problem for connected beams. European Journal of Applied Mathematics V 18, N:01, pp 21-55 (2007).

2. J. Liu, G. Nakamura, M. Sini, Reconstruction of the shape and surface impedance from acoustic scattering data for arbitrary cylinder. SIAM J. Appl. Math, V 67, N 4, pp 1124-1146 (2007).

3. J.J Liu, J. K. Seo, M. Sini and E. J. Woo, On the convergence of the harmonic B_z algorithm in MREIT. SIAM J. Appl. Math, V 67, N 5, pp 1259-1282 (2007).

4. G. Nakamura and M. Sini, Obstacle and boundary determination from scattering data. SIAM J. Math. Anal, V:39, N: 3 p:819-837

5. N. Honda, G. Nakamura, R. Potthast and M. Sini, The no-response approach and its relation to other sampling methods. Annali di Matematica Pura ed Applicata. At press.

Submitted

6. C-L. Lin, G. Nakamura and M. Sini, Unique continuation for transversally isotropic dynamical systems and its applications. Accepted by SIAM J. Math. Anal.

7. F. Cakoni, M. Sini and N. Zeev, The identification of a partially coated dielectric from far field measurements.

8. E. Sincich and M. Sini. Local stability for soft obstacles by a single measurement. Submitted.

9. R. Potthast and M. Sini. The No Response test for the reconstruction of polyhedral objects in electromagnetism.

10. L. He, S. Kindermann and M. Sini. Reconstruction of shapes and surface impedances using few farfield measurements.

Marie-Therese Wolfram advised by Prof. Heinz W. Engl

Marie-Therese Wolfram started her PHD, which is supervised by Prof. Martin Burger, in October 2005 at RICAM. Prof. Burger accepted an offer of a full professorship in 2006 from the University of Münster. Ms. Wolfram worked as a research assistant at the University of Münster from November 2006 to October 2007. In October 2007 returned to RICAM to finish her PHD-thesis.

Scientific Achievements 2007

Ion Channels and Nanopores

A well known model for ion channels are the Poisson-Nernst-Planck (PNP) equations, which describe the movement of charged particels through a permeable membrane. During the last year we were working on different numerical methods for solving the PNP equations, such as exponential fitting and mixed finite element methods. We developed a stable finite element approach to solve the PNP equations for 2D and 3D simulations. Furthermore we tried to incorporate chemical reactions such as precipitation and solvation into the PNP equations to model plugging in nanopores.

This is joint work with Prof. Martin Burger, Prof. Robert Eisenberg, Prof. Joachim Schöberl, Dr. Herbert Egger and DI Astrid Sinwel.

Numerical Methods in Optimal Transport
During the last years optimal mass transport problems became quite popular in the mathematical community. While the theoretical properties are studied extensively, numerical simulations received little attention.
In the last year we worked on mixed finite element methods for the Patlak-Keller-Segel model, the porous medium equations and the relativistic heat equation. This is joint work with Prof. Martin Burger and Prof. Jose Carrillo.

Workshops, Conferences and Scientific Talks

Workshops & Conferences

- WONAPDE 2007, Second Chilean Workshop on Numerical Analysis of Partial Differential Equations, 16.01-19.01.2007 in Concepcion, Chile
- International Congress on Industrial and Applied Mathematics, 16.07-20.07.2007 in Zurich, Switzerland
- Slovak-Austrian Mathematical Congress, 16.9-21.9.2007 in Podbanske, Slovakia
- Workshop on Ion Channels, 8.10-12.10.2007 at the Special Semester on Quantitative Biology analyzed by Mathematical Methods, RICAM, Linz

Scientific Talks

- Martin Burger, Marie-Therese Wolfram, *"Forward and Inverse Solvers for Drift-Diffusion Systems"*, WONAPDE, Chile, 17.1.2007
- Marie-Therese Wolfram, *"Forward Solvers for Ion Channels"*, ICIAM, Zürich, 16.07.2007
- Marie-Therese Wolfram , *"Numerical Methods for Ion Channels"*, Slovak-Austrian Mathematical Congress, Slovakia, 20.09.2007
- Martin Burger, Marie-Therese Wolfram, *"Numerical Simulation of Ion Channels using Finite Elements*", Workshop on Ion Channels, Linz, 10.10.2007
- Marie-Therese Wolfram, *"Numerical Methods for Non-Linear Fokker-Planck Equations"*, Wolfgang Pauli Institute, Vienna, 8.08.2007

Scientific Cooperations

Internal
Dipl.-Math. techn. Kattrin Arning
DI Astrid Sinwel

External
Prof. Martin Burger (University of Münster)
Prof. Robert S. Eisenberg (Rush University Medical Center, Chicago)
Prof. Jose A. Carrillo (Universitat Autonoma de Barcelona)
Prof. Joachim Schöberl (RWTH Aachen)
Dr. Herbert Egger (RWTH Aachen)

Clemens A. Zarzer advised by Prof. Dr. Heinz W. Engl

Work before joining RICAM

Clemens Zarzer graduated in August 2007 at the Technical University of Eindhoven in the double degree master studies Industrial and Applied Mathematics. According to the double degree program the graduation at the Johannes Kepler
University Linz followed in September 2007. Most of this year's work was dedicated to his master thesis on 'The Optical Maskless Lithography Rasterization Problem', which was a cooperation with the company ASML Netherlands.
Since September 2007 he is working in the framework of the WWTF project MA 05: "Modeling the Dynamics of Cellular Networks Using Inverse Methods" as a Ph.D. student advised by Prof. Dr. Heinz W. Engl and Dr. Philipp Kügler.

Scientific Achievements 2007

In the months that he has been employed, Clemens Zarzer has worked on several aspects of the WWTF project "Modeling the Dynamics of Cellular Networks Using Inverse Methods", including software testing and documentation and assisting in the development. Furthermore, first steps toward theoretical results in the framework of regularization of inverse problems using sparsity-promoting techniques were made. Clemens Zarzer also continued to make himself familiar with the biological and chemical background knowledge in Systems Biology.

Scientific Cooperations

Internal
Dr. Philipp Kügler
Dr. James Lu
Dr. Stefan Müller

External
Dr. Christoph Flamm
Mag. Rainer Machne

Participation at Conferences, Scientific Visits and Talks Conferences (including talks)

Special Semester on Quantitative Biology analyzed by Mathematical Methods – Workshop on Systems Biology, Johannes Kepler Universität Linz

4.4 GROUP "SYMBOLIC COMPUTATION"

Group Leader:
Ao.Univ.-Prof. Dr. Josef Schicho

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Martin Giese
Dr. Markus Rosenkranz
Ao.Univ.-Prof. Dr. Josef Schicho
Dr. David Sevilla
Dipl.-Ing. Alexander Zapletal
Dr. Tobias Beck

Researchers externally funded:
MSc. Jose-Manuel Garcia-Vallinas
MSc. Mario Kapl
MSc. Niels Lubbes
MSc. Brian Moore
Dr. Georg Regensburger

Introduction by Group Leader Prof. Josef Schicho

In symbolic functional analysis, the group members have developed a symbolic approach to differential/integral equations with boundary conditions based on factorisation. These contributions come from Regensburger and Rosenkranz. The results are encouraging; the theory is still quite recent, hence it is planned to continue this branch of research also after the SFB project is finished.

In the other two subprojects of the SFB, new algorithms for parametrization and approximate implicitization have been developed, by Beck, Schicho, and Jüttler and Shalaby from the University of Linz.

In a project together with H. Hauser (Univ. Vienna), Lubbes and Schicho started to develop a method for constructing families of rational curves on algebraic surfaces. This has potential applications in Computer Aided Geometric Design and also in the parametrizaiton problem.

Topological methods started to appear in several contexts: an algebraic question could be solved by topology by Schicho, Landsmann and Mayr (the last two are from the University of Linz); and a symbolic method for computing critical points on an algebraic surface was developed by researchers from the University of Alcala and Schicho, originally to answer topological questions.

In June, RICAM organized MEGA 2007. MEGA is a series of roughly biannual conferences on computational and application aspects of algebraic geometry and related topics, with very high standards.

Plans for 2008 and 2009:

Apart from continuation of the successfull research branches and cooperations, there will be an additional emphasis on approximate algebraic computation. The SFB will end in 2008, but Schicho will lead a project in the Doktoratskolleg "Computational Mathematics: Numerical Analysis and

Symbolic Computation", a successor of SFB on a smaller scale. Starting in autumn 2008, it is planned to employ a new PhD student for approximate genus computation and approximate parametrizations. Also here, topological methods are foreseen to be relevant.

David Sevilla (Univ. Montreal) has joined RICAM as a PostDoc in autumn 2007. His background is computational algebra. He has expertise in functional decompositions of rational functions and automorphisms of function fields. It is planned to involve him in a project for developing theories and constructions for root parametrizations of algebraic curves. If successfull, this research would be groundbreaking for new applications for curve parametrizations, since a much larger class of algebraic curves can potentially be treated that way.

Dr. Tobias Beck

Scientific Achievements 2007

Beck has further clarified the concept of *formal desingularizations*. These now form a nice theory and are based on solid foundations. Moreover, there is now a clean and stable implementation in MAGMA. A paper has been submitted to the Journal of Symbolic Computation. An application of formal desingularizations is the computation of adjoints spaces for surfaces. Here, a paper is near completion. Finally, the implementation of a fully automatized parametrization algorithm for algebraic surfaces over the rational numbers has been started.

Beck has resumed the cooperation with Klaus Scheicher (which involves the external collaborators Horst Brunotte and Jörg Thuswaldner) and the results have been recorded in a technical report and submitted to the Mathematical Proceedings of the Cambridge Philosophical Society.

Scientific Cooperations

Internal
The work on number systems and tilings over Laurent series rings together with Klaus Scheicher from the group Financial Mathematics (and external collaborators) has been completed (see Technical Report).

External
Beck has discussed the relation of formal desingularizations and arc spaces with Clemens Bruschek from the University of Innsbruck. He has also spent a month in Sydney to improve the implementation of the algorithm for formal desingularization together with the local experts, in particular Michael Harrison.

Participation at Conferences, Scientific Visits and Talk

- Visit with Jörg Thuswaldner to finish the joint article (see Technical Report), Leoben, Austria, May 2 - 4, 2007
- Talk "Three Problems in the Context of Formal Desingularization", Workshop on Resolution of Algebraic Varieties, Nove Hrady, May 21 - 24, 2007
- Visit at Herwig Hauser's group to discuss the possible further development of the concept of formal desingularizations with Shihoko Ishii, Innsbruck, Austria, June 13 – 14, 2007
- MEGA Conference 2007 (Effective Methods in Algebraic Geometry), Strobl, Austria, June 25 - 28, 2007
- Visit at the MAGMA development group to introduce/improve the implementation of the algorithm for formal desingularization to/with the local experts, Sydney, Australia, August 4 – September 2, 2007

- Talk "Formal Desingularization of Surfaces - Jung's Method Revisited", Compass 2007 (Computational Methods for Algebraic Spline Surfaces), Strobl, Austria, September 10 – 11, 2007

Publications 2007

Technical Report
T. Beck, H. Brunotte, K. Scheicher and J.M. Thuswaldner: Number Systems and Tilings over Laurent Series, RICAM-Report 2007-17
T. Beck: Formal Desingularization of Surfaces - The Jung Method Revisited -, RICAM-Report 2007-31

Published
T. Beck, J. Schicho: Parametrization of Algebraic Curves Defined by Sparse Equations. AAECC, Bd. 18(1/2), S. 127-150, 2007
T. Beck, J. Schicho: Curve Parametrization over Optimal Field Extensions Exploiting the Newton Polygon. In: B. Jüttler, R. Piene (Editors), Geometric Modelling and Algebraic Geometry (FSP Workshop on Computational Methods for Algebraic Spline Surfaces); Berlin/Heidelberg: Springer, S. 119-140 , 2007

Software
T. Beck: Efficient Surface Tool Box – A MAGMA Software Package – http://www.ricam.oeaw.ac.at/software/symcomp/surfaces.tar.gz , December 2007

José Manuel García Vallinas advised by Prof. Josef Schicho

Scientific Achievements 2007

He was an organizer of the conference MEGA 2007 (local organizer and proceedings editor). Afterwards, he left RICAM and became a teacher in a high school. Originally, G.-V. wanted to write a PhD thesis on numeric-symbolic problems in computational algebraic geometry, under the advise of J. Schicho. But it turned out that he has more affinity to education than to research.

Participation at Conferences, Scientific Visits and Talk

Conferences
Effective Methods in Algebraic Geometry (MEGA) 2007, Strobl, June 25-29.

Dr. Martin Giese

Scientific Achievements 2007

M. Giese has written an introductory text on first-order logic with subtyping and on formal reasoning for this logic, which is going to appear as a chapter of the upcoming book about the KeY system [8]. He has also published an extended account on some earlier work on equality handling in free variable tableaux.

Scientific Cooperations

External

- Cooperation with B. Buchberger, T. Kutsia and other RISC members, concerning the reflection mechanism, questions of the design of a mathematical proof assistant, and generation of Java code.
- Cooperation with members of the KeY project at University of Karlsruhe, Germany, University of Koblenz, Germany, and Chalmers University, Göteborg, Sweden in the preparation of the upcoming book about the KeY system [8].
- Cooperation with J. Kiniry, University College Dublin, Ireland, in the preparation of a joint project proposal.

Publications 2007

1. M. Giese, Superposition-based Equality Handling for Analytic Tableaux, Journal of Automated Reasoning 38(1-3):127-153, 2007
2. M. Giese, Chapter on First-Order Logic in: Verification of Object-Oriented Software—The KeY Approach, Springer, Lecture Notes in Computer Science 4336, 2007.

Scientific plans for 2007

M. Giese left RICAM on March 1, 2007.

Mario Kapl advised by Prof. Josef Schicho

He is a PhD student of B. Jüttler.

Scientific Achievements 2007

Mario Kapl has continued his work on weighted spline wavelets. Weighted spline wavelets are wavelets that are adapted to the region of interest by means of a weighted inner product. In addition to weighted biorthogonal spline wavelets, he has constructed weighted semiorthogonal spline wavelets, i.e. semiorthogonal wavelets with respect to a weighted inner product. These wavelets have been used to describe a tensor-product spline wavelet construction which is based on the one-dimensional wavelet transform. Furthermore he has considered different applications of this tensor-product spline wavelet construction and has compared it with standard uniform ones. One example has been the construction of a wavelet representation of implicitly defined spline curves for which the region of interest - the curve - is preserved better than for existing uniform wavelets.

Participation at Conferences, Scientific Visits and Talks Conferences (including talks)

- FSP Workshop on Computational Methods for Algebraic Spline Surfaces, September 10-14, 2007, Strobl, Austria. Talk: Multiresolution Analysis with Weighted Spline Wavelets
- SFB-Statusseminar 2007, April 12-14 2007, Strobl, Austria. Talk: Weighted Spline Wavelets
- 12th International Conference in Approximation Theory, March 4-8, 2007, San Antonio, Texas, USA. Talk: Weighted Spline Wavelets

Publications

1. M. Kapl and B. Jüttler. Multiresolution Analysis for Implicitly Defined Algebraic Spline Curves with weighted Wavelets; Approximation Theory 12, San Antonio 2007, M. Neamtu and L. Schumaker (eds.), Nashboro Press, to appear.

Niels Lubbes advised by Prof. Josef Schicho

He is a PhD student of Schicho working in a joined RICAM in FWF-project P18992, led by Schicho and H. Hauser (Univ. Innsbruck).

Conference (Talk)

- "Line Bundles and Rational Maps", Workshop on algebraic geometry (Nove Hrady, Czech Republic, Mai 2007).

Scientific visit

- Several visits to the University of Innsbruck, participating seminars organized by H. Hauser.

Brian Moore advised by Prof. Josef Schicho

He is writing a PhD thesis on the solutions of algebraic systems arising in robotics.

Scientific Achievements 2007
His investigations concerning the balancing of parallel mechanisms (together with J. Schicho and C. Gosselin) lead to a complete chararacterization of statically balanced four-bar mechanisms. Although this case is computationally easy, the method based on toric geometry can be used to systematically prove the completeness of the solution set. Moreover, using appropriate elimination of the joint velocities as well as a new toric polynomial division algorithm, the complete set of dynamically balanced planar four-bar mechanisms has also been derived.

He was also working on a Bézier clipping method for the computation of the real roots of two bivariate polynomials (together with B. Jüttler).

Scientific cooperation

External
- Bert Jüttler (Univ. Linz): development of a Bezier clipping method for the computation of the real roots of two bivariate polynomials.
- Clément M. Gosselin, Laval University, Quebec, Canada: classification of dynamically balanced parallel robots.

Participation at Conferences, Scientific Visits and Talks

Conferences
[1] IMA Annual Program Year Workshop: Non-Linear Computational Geometry, Minneapolis, USA, May 2007, Poster: Static balancing of parallel mechanisms
[2] Conference on Geometry, Theory and Application, Vorau, Austria, June 2007 Talk: Computing intersections of planar algebraic curves using bivariate quadratic clipping
[3] MEGA 2007: Effective Methods in Algebraic Geometry, Strobl, Austria, June 2007 Talk: Static balancing of parallel mechanisms
[4] Workshop on Computational Methods for Algebraic Spline Surfaces, Strobl, Austria, September 2007, Talk: Determination of the complete set of statically balanced planar four-bar mechanisms
[5] Mathematical Aspects of Computer and Information Sciences 2007, Paris, France, December 5-7, 2007, Talk: Computing roots of polynomials using bivariate quadratic clipping

Scientific Talks
[6] SFB Status Seminar, Strobl, Austria, April 2007
Talk: Solutions of polynomials equations using quadratic clipping
[7] INRIA Sophia-Antipolis, Galaad seminar, France, April 2007
Talk: Computing intersections of planar algebraic curves using bivariate quadratic clipping

Publications

Submitted
[9] Brian Moore, Josef Schicho, Clément M. Gosselin: Determination of the complete set of statically balanced planar four-bar mechanisms, July 2007. (SFB Report 2007-14).
[8] Brian Moore, Josef Schicho, Clément M. Gosselin: Dynamic balancing of planar mechanisms using toric geometry, November 2007. (SFB Report 2007-28).

Dr. Georg Regensburger

He is a PostDoc working in the SFB, subproject F1322.

Scientific Achievements 2007

A central topic of G. Regensburger's work is on boundary problems within the SFB project F1322 "Computer Algebra for Pure and Applied Functional Analysis". With M. Rosenkranz he developed an algebraic framework for factoring linear boundary problems and the corresponding Green's operators.
For linear ordinary differential equations, the main results can be made algorithmic. They define an abstract boundary problem as a pair consisting of a surjective linear map ("differential operator") and an orthogonally closed subspace of the dual space ("boundary conditions"); this includes in particular boundary problems for (systems of) ordinary and partial differential equations. The general results on factorizations can be used for example for factoring higher-order boundary problems into lower-order subproblems with transformed boundary conditions. See the report of M. Rosenkranz for further details.
G. Regensburger also applied symbolic methods to the construction of parametrized wavelets and their applications. Moreover, he continued his research on generalized solutions of nonlinear first-order ordinary boundary problems and the max-plus algebra.
With M. Rosenkranz he worked on a cooperation with the Financial Mathematics Group (C. Constantinescu and H. Albrecher) on symbolic computation for boundary problems in risk theory (see also the report of C. Constantinescu).

Scientific Cooperations

Internal
G. Regensburger works with M. Rosenkranz in the SFB project F1322 led by Prof. B. Buchberger (RISC) and Prof. H. W. Engl. There is an ongoing cooperation between the Symbolic Computation Group (G. Regensburger and M. Rosenkranz) and the Financial Mathematics Group (C. Constantinescu and Prof. H. Albrecher). G. Regensburger cooperates also with S. Müller from the Inverse Problems group on symbolic methods for systems biology (in particular, in bifurcation analysis).

External
- With the Theorema group at RISC led by Prof. B. Buchberger.
- With Prof. Alan Park (Korea Institute for Advanced Study) he edited the proceedings [6] of the workshop "Gröbner Bases in Control Theory and Signal Processing".

- With Prof. Katsuhisa Horimoto (National Institute of Advanced Industrial Science and Technology, Japan) and M. Rosankranz he co-organizes the conference Algebraic Biology 2008 in Hagenberg, Austria and co-edits the proceedings, which will appear in the Springer LNCS series.
- With Dr. Manuel Kauers (RISC) he cooperates on symbolic methods for parametrized linear differential equations.

Participation at Conferences, Scientific Visits and Talks

Conferences and Workshops

[1] Workshop on Systems Biology, within the Special Semester on Quantitative Biology analyzed by Mathematical Methods, RICAM, Linz, Austria, November 5–9.

[2] ACA07, Applications of Computer Algebra, Oakland University, Rochester, MI, USA, July 19–22.
Talk: "Optimal Filter Design with Parametrized Wavelets".

[3] Algebraic Biology 2007, RISC, Hagenberg, Austria, July 2–4.

[4] Workshop Algebraic Geometry, Nové Hrady, Czech Republic, May 22–23.
Talk: "Generalized Solutions for nonlinear first-order ODEs and Max-plus Interpolation".

[5] SFB Statusseminar, Strobl, Austria, April 12–14.
Talk with M. Rosenkranz: "Solving and Factoring Boundary Problems in Differential Algebra".
Talk with M. Rosenkranz: "Abstract Boundary Problems and Applications".
Talk: "Applications of Wavelets Parametrized by Moments".

Publications 2007

Appeared
[1] H. Park, G. Regensburger (eds.), Gröbner Bases in Control Theory and Signal Processing, Radon Series on Computational and Applied Mathematics, vol. 3, Walter de Gruyter & Co, Berlin, 2007.

[2] G. Regensburger, Applications of filter coefficients and wavelets parametrized by moments, in [6], pp. 191– 214, 2007.

[3] G. Regensburger, Parametrizing compactly supported orthonormal wavelets by discrete moments, Appl. Algebra Engrg. Comm. Comput., 18(6):583–601, 2007.

Accepted
[4] M. Rosenkranz and G. Regensburger, Solving and Factoring Boundary Problems for Linear Ordinary Differential Equations in Differential Algebras, Journal of Symbolic Computation, 2007, accepted.

[5] G. Regensburger and M. Rosenkranz, An Algebraic Foundation for Factoring Linear Boundary Problems, Ann. Mat. Pura Appl. (4), 2007, accepted.

Dr. Markus Rosenkranz

Scientific Achievements

Based on the ideas of his dissertation ("A Polynomial Approach to Boundary Value Problems", available as RISC Technical Report 2003-05), an **algebraic theory of linear boundary problems** has been built up. In close cooperation with Georg Regensburger, this theory has been extended and generalized in three major directions during 2007:

The **classical setting** of two-point boundary problems has been superseded by an abstract theory [4] that encomposses a wide class of differential algebras (including the classical one). It allows arbitrary Stieltjes boundary conditions in addition to the usual two-point conditions. A multiplication for boundary problems was found that corresponds exactly to the composition of their Green's operators. Any factorization of the underlying linear differential operator can be lifted (algorithmically!) to a decomposition of boundary problems.
The linear integro-differential operators occurring in [4] have led to the new notion of **integro-differential polynomials**, which can be seen as a natural generalization of differential polynomials (algebraic version of nonlinear differential operators). This construction is currently analyzed and will be published early in 2008.
In a more **abstract approach**, the theory does not rely on any notion of differentiation; a boundary problem is defined as an arbitrary linear endomorphism on a vector space together with an orthogonally closed subspace of its dual. Despite its generality, this approach allows to develop a significant portion of the algebraic theory of boundary problems [5]. Regularity, multiplication and factorization can be defined such that it subsumes important classes of boundary problems—the classical two-point setting, linear systems of ODEs, linear PDEs.

The last claim is supported by a detailed algebraic study of the **one-dimensional wave equation** (one space dimension plus one time dimension). The obvious factorization of the differential equation is lifted to various boundary problems, including the classical Dirichlet problem on an interval. In the latter case, the boundary conditions of the left factor involve line integrals diagonal to the space-time grid. This factorization yields a geometrically illuminating decomposition of the Green's operators, tracing a zig-zag line (left factor) along the diagonal under the test point (right factor).

Currently a new **implementation** of integro-differential operators/polynomials is under way. A *Mathematica* package is being set up for computing in integro-differential algebras, for calculating with Green's operators, and for solving boundary problems.

Scientific Cooperations

Internal

The research topic of algebraic boundary problems is embedded as Subproject F1322 "**Symbolic Functional Analysis**" within the SFB F013 "Numerical and Symbolic Scientific Computing" funded by the FWF. Jointly initiated and supervised by Prof. Buchberger (RISC) and Prof. Engl, it benefits from stimulating inputs both from analysis/numerics (Prof. Engl) and computer algebra (Prof. Buchberger).

A cooperation between the Symbolic Computation Group (M. Rosenkranz and G. Regensburger) and the Financial Mathematics Group (C. Constantinescu and Prof. Albrecher) has led to **new results in collective risk theory**. Using the symbolic calculus of boundary problems, we have developed exact solution formulae for Gerber-Shiu functions in renewal setting; see the report by Corina Constantinescu for more details. We have written a joint research proposal that qualified for the final round of the 2008 Individual Grant Competition (organized by The Actuarial Foundation's AERF Committee, Casualty Actuarial Society and Society of Actuaries' CKER).

External

Together with Prof. Dongming Wang (Cheung Kong Professor and CNRS Research Director, School of Science Beihang University, Beijing, China), Markus Rosenkranz has edited a proceedings volume "**Gröbner Bases in Symbolic Analysis**" based on the workshop D2 of the Special Semester on Gröbner Bases (organized in 2006 at RICAM), published by de Gruyter in [6].

As a project co-supervised by Prof. Buchberger, Symbolic Functional Analysis entertains close working relations with the **Theorema group** (RISC) conducted by Prof. Buchberger. Ideas are exchanged especially through the Theorema seminar, based on the vision that symbolic computation is a form of specialized reasoning. One particular cooperation topic concerns the algorithmization of general polynomial domains in various flavors (Weyl algebra, differential polynomials, free noncommutative algebra, etc) using Prof. Buchberger's conception of functors in Theorema.

With Katsuhisa Horimoto (National Institute of Advanced Industrial Science and Technology, Japan) and G. Regensburger, Markus Rosenkranz co-organizes the conference **Algebraic Biology 2008** in Hagenberg, Austria, and co-edits the proceedings, which will appear in the Springer LNCS series.

Participation at Conferences, Scientific Visits and Talk

Conferences
[1] Member of the Poster Committee of the International Symposium on Symbolic and Algebraic Computation (ISSAC), Waterloo, Ontario, Canada, July 29-August 1, 2007.

Scientific Talks
[2] M. Rosenkranz, G. Regensburger, Solving and Factoring Boundary Problems in Differential Algebra, SFB Statusseminar, Strobl, Austria, April 12-14.
[3] G. Regensburger, M. Rosenkranz, Abstract Boundary Problems and Applications, SFB Statusseminar, Strobl, Austria, April 12-14.

Publications

Accepted
[1] M. Rosenkranz and G. Regensburger, Solving and Factoring Boundary Problems for Linear Ordinary Differential Equations in Differential Algebras, *Journal of Symbolic Computation*, 2007, accepted (also available as SFB Report 2007-8).
[2] G. Regensburger and M. Rosenkranz, An Algebraic Foundation for Factoring Linear Boundary Problems, *Ann. Mat. Pura Appl.* (4), 2007 accepted (also available as SFB Report 2007-9).

Appeared
[3] M. Rosenkranz and D. Wang (ed.), Gröbner Bases in Symbolic Analysis, Radon Series on Computational and Applied Mathematics 2. Walter de Gruyter & Co., Berlin, 2007.

Prof. Josef Schicho

Scientific Achievements 2007

With T. Beck, he adapted algorithms for curve parametrization that take advantage of the sparsity of the input polynomial. He could also make a contribution to an investigation of S. Widder and P. Schuster (Univ. Wien) of dynamic patterns of gene regulation. Together with H.-C. Graf von Bothmer (Univ. Hannover), O. Labs (RICAM), C. van de Woestijne (Univ. Leiden), he could prove some cases

of the Casas-Alvero conjecture on univariate polynomials. Together with J. R. Sendra and J. G. Alcazar from the University of Alcala, Spain, he developed a symbolic algorithm for the computation of the topological type of the level sets of algebraic surfaces. Together with B. Jüttler and M. Shalaby, he devised an algorithm for approximate implicitization.

He was the main organizer of the conference Effective Methods in Algebraic Geometry (MEGA 2007) in St. Wolfgang. The help of other members of the group (J. Garcia Vallinas, T. Beck) and of the RICAM staff (M. Fuchs) in the conference organization should also be mentioned. As a followup of the conference, he is editing a special issue of MEGA-related papers in the Journal of Symbolic Computation, together with A. Galligo (Univ. Nice, France) and L. Pardo (Univ. Cantabria, Spain). He also edited together with J. R. Sendra (Univ. Alcala) a special issue on algebraic curves in the AAECC journal.

Scientific Cooperations

Internal
- T. Beck: 2 joint papers.
- O. Labs (now Univ. Saarbrücken): 1 joint paper (also joint with H.-C. von Bothmer, Univ. Hannover, and C. van de Woestijne, Univ. Graz).
- H. K. Pikkarainen: 1 joint paper planned.

External
- Bert Jüttler, Linz: 1 joint paper (also joint with M. Shalaby, former PhD student of Schicho, then PostDoc in a project by Jüttler), joint organization of conference Computational Methods for Algebraic Spline Surfaces (COMPASS 2007).
- Herwig Hauser, Innsbruck: 1 joint FWF project which started in October 2006.
- Rafael Sendra, Madrid: 1 special issue in a journal jointly edited, 1 joint paper (also joint with J. G. Alcazar, a PhD student of Sendra).
- Peter Schuster and Stephanie Widder: 1 joint paper.
- Günter Landsmann (Linz) and Peter Mayr (Linz): 1 joint paper.
- Christian Haase (Berlin): 1 joint paper.
- Luis Miguel Pardo, Univ. Cantabria, A. Galligo, Nice: 1 special issue in preparation.
- D. Cox (Amherst College), A. Dickenstein (Buenos Aires), H. Schenck (Univ Illinois): orgainization of a miniworkshop on Surface Modeling and Syzyies in Oberwolfach.

Participation at Conferences, Scientific Visits and Talks.

Invited Conference Talks

J. Schicho	Resolution of Singularities in Characteristic Zero	Applications of Groebner Bases, RIMS Workshop, Kyoto 2007, 2007
J. Schicho	Blowing Them Up	Workshop on Singularities, Valladolid 2007, 2007
J. Schicho	Families of Rational Curves on Surfaces	Colloquium on the Graduiertenkolleg Methods for Discrete Structures, Berlin 2007
J. Schicho	Families of Rational Curves on Surfaces	Surface Modeling and Syzygies, Miniworkshop, Oberwolfach 2007
J. Schicho	Numerical Implicitization	Surface Modeling and Syzygies, Miniworkshop, Oberwolfach 2007

Contributed Conference Talks

B. Moore, J. Schicho, C. Gosselin	Static balancing of parallel mechanisms	MEGA 2007: Effective Methods in Algebraic Geometry, Strobl, Austria, June 2007
B. Moore, J. Schicho, C. Gosselin	Static balancing of parallel mechanisms	IMA Annual Program Year Workshop: Non-Linear Computational Geometry, Minneapolis, USA, May 2007
J. Schicho	Linear Systems of Plane Curves	Workshop Algebraic Geometry, Nove Hrady 2007, 2007

Publications 2007

Articles in Journal

T. Beck, J. Schicho	Parametrization of Algebraic Curves Defined by Sparse Equations	AAECC, 18(1/2):127--150, 2007	
M. Shalaby, B. Jüttler, J. Schicho	Approximate Implicitization of Planar Curves by Piecewise Rational Approximation of the Distance Function	AAECC, 18(1/2):71--89, 2007	
J. R. Sendra, J. Schicho	Special issue on algebraic curves	AAECC, 18(1/2):1--2, 2007	
J. G. Alcazar, J. Schicho, J. R. Sendra	A Delineability-based Method for Computing Critical Sets of Algebraic Surfaces	J.Symb.Comp., 42(6):678--691, 2007	
S. Widder, J. Schicho, P. Schuster	Dynamic patterns of gene regulation {I}: simple two-gene systems	J. Theoret. Bio., 246:395--419, 2007	
C. Haase, J. Schicho	Lattice polygons and the number 2i+7	Math. Monthly, 2007	accepted
G. Landsmann, P. Mayr, J. Schicho	A topological property of polynomial functions on {GL(2,R)}	Aequationes Mathematicae, 73(1--2):71--77, 2007	
H.-C. Graf v. Bothmer, O. Labs, J. Schicho, C. van de Woestijne	The {Casas-Alvero} {Conjecture} for infinitely many degrees	J. Algebra 316 (1): 224--230, 2007	
T. Beck, J. Schicho	Curve Parametrization over Optimal Field Extensions Exploiting the {Newton} Polygon	Proc. Compass 2005. Springer, 2007	

Dr. David Sevilla González

Introduction

The research area of Dr. Sevilla González is Symbolic Computation. He has worked on functional decomposition, and recently he studied computational aspects of Monstrous Moonshine.

Scientific Achievements in 2007

Research in 2007 before RICAM

Before coming to RICAM, Dr. Sevilla González worked at Concordia University in Montreal, where he collaborated with Pr. John McKay in studying several computational questions arising in the area of Monstrous Moonshine. In particular, he used his knowledge of rational function decompositions to compute the poset of replicable functions.

Research in 2007 at RICAM

At RICAM, Dr. Sevilla González has worked on the topic of root parametrizations of curves in collaboration with Pr. Josef Schicho.

They are working on the problem of finding root parametrizations from several angles. One theoretical approach is to find families of curves that generalize the well-studied hyperelliptic case, that is, the case where there exists a 2:1 map to the projective line. In particular, any curve for which an n:1 map onto the projective line exists for n less than 5 can be root parametrized, hence the interest in determining such families.

A more computational approach that is being developed is devising algorithms that compute root parametrizations. They are currently working on programing an algorithm that computes quotient of curves in order to detect a hyperelliptic or elliptic quotient, from which a root parametrization is computed. This algorithm is being written in Magma and Maple at the moment.

Publications

Decomposing replicable functions, with John McKay, Journal of Computation and Mathematics (to appear).

Alexander Zapletal advised by Prof. Bruno Buchberger

He is a PhD student of Bruno Buchberger, the former co-leader of the group.

Scientific Achievements 2007

A. Zapletal worked on his PhD thesis, “Compiling Theorema programs to Java”. The compiler, which he implements under the direction of Bruno Buchberger and Martin Giese, could lead to a drastic speed-up of the computational facility of Theorema. Having this system in hand, a formal knowledge base for Gröbner bases will be build up within it. This will be done in close cooperation with the RISC institute.

Scientific Cooperations

External
Close cooperation with the Research Institute for Symbolic Computation (RISC), Johannes Kepler University of Linz. A. Zapletal participates in the weekly Theorema seminar and also in other seminars which are related to the redesign of the Theorema system.

Scientific plans for 2008

A. Zapletal will leave RICAM on 1 October 2007 in order to be closer to his advisor Bruno Buchberger. Presumable, he will finish his PhD thesis in the year 2008.

4.5 GROUP "FINANCIAL MATHEMATICS"

Group Leaders:
Univ.-Prof. Dr. Hansjörg Albrecher
o.Univ.-Prof. Dr. Walter Schachermayer

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Corina Constantinescu
Dr. Markus Hahn (part-time; started in October 07)
Dr. Gottlieb Pirsic (until March 07)
Dr. Jean-Francois Renaud (started in August 07)
Dr. Jörn Sass
Dr. Klaus Scheicher (until September 07)
Univ.-Doz. Dr. Arne Winterhof

Researchers externally funded:
Dr. Nina Brandstätter
Dr. Domingo Gomez (until October 07)
Dr. Markus Hahn (until September 07)
DI Dominik Kortschak
DI Philip Ngare
Dr. Gottlieb Pirsic (started in April 2007)
DI Wolfgang Putschögl
DI Stefan Thonhauser

Introduction by Group Leader Prof. Hansjörg Albrecher

The aim of this research group is the concentration and the further development of different competences to handle problems from mathematical finance and insurance. This includes the development, calibration and analysis of stochastic models for the corresponding real-world processes, questions of optimal choice of control parameters in order to reach a given risk or profitability target and the computational issues relevant for this approach. Among the topics of current research are portfolio optimization under partial information and under transaction costs, utility maximization in incomplete financial markets (based on duality characterizations of portfolios), valuation and semi-static hedging of financial derivatives in general market models, investigation of risk measures for a surplus process of a portfolio of insurance contracts, complexity reduction for high-dimensional integration as well as generation and analysis of pseudorandom numbers.

In January 2007, Dr. Corina Constantinescu (PhD from Oregon State University, USA) joined the group and later in the year Dr. Jean-Francois Renaud (PhD from Universitè de Montreal) started as a PostDoc. At RICAM they now both work, from different perspectives, on analytical aspects of risk analysis and the interplay between financial and insurance mathematics. Since October, Prof. Albrecher works in Linz full-time, partially financed by the Johannes-Kepler University of Linz.
Currently there are three on-going FWF projects within the group:

- "Mathematical Models for Insurance Risk" (led by Prof. Albrecher)
- "Computing optimal portfolios under partial information" (led by Dr. Sass)
- "Pseudo-Random Sequences" (led by Doz. Winterhof)

employing 3 PhD students and 2 PostDocs, so that together with an additional PhD student financed by the Austrian Exchange Service, about half of the group members employed at RICAM are financed through third-party funds. A joint research project with Joanneum Research, the Wegener Center and ZAMG on the mathematical and economic analysis of weather and climate risks in Austria has recently been granted by the Jubilee Foundation of the Austrian National Bank. This will provide an additional PhD position in the group on from Spring 2008.

In 2007, for portfolio optimization under partial information the utility maximization problem under a shortfall risk constraint was solved and strategies were derived, and these results were applied to a hidden Markov model for the drift of the stock returns, where the drift process has to be filtered from observations. Convex and dynamic constraints were also considered. Markov chain Monte Carlo methods to estimate relevant parameters in Markov switching models and certain non-constant volatility models were further developed. As a feasible alternative for larger sample sizes, a method of moments combined with a linear regression was used for the estimation of the parameters. Further, optimal consumption strategies have been considered under partial information and explicit consumption and investment strategies were derived under fairly general conditions.
In risk theory, asymptotic results for tail probabilities of dependent sums were obtained for non-identical marginal distributions. Also, new integral representations for ruin probabilities under Pareto-type claim sizes were derived. The effects of economic factors on risk measures in the portfolio were further investigated from several perspectives within the group. For instance, the recently obtained simple formula for the probability of ruin in the classical risk model in the presence of tax payments according to a loss-carry forward system (as well as the formulae for the corresponding moments of tax payments and criteria for optimal taxation levels) could be extended to general spectrally negative Levy risk processes and to a dual risk model. This analysis contributed significantly to the understanding of the structural reason for the striking simplicity of these relations. Furthermore, asymptotic decay rates of ruin probabilities for renewal jump-diffusion processes could be identified.
The stochastic control problem to find the optimal dividend payment strategy in an insurance portfolio with interest on the free surplus was solved.

In another series of research activities, the analysis of pseudorandom number generators for quasi-Monte Carlo applications, for cryptographic applications and applications in algorithmic number theory were continued in 2007. A new class of nonlinear pseudo-random number generators with a linear complexity profile lower bound of exponential size (in the logarithm of the sequence length) has been identified which is defined by recursions with Redei functions. This result gives rise to a strong candidate for cryptographic purposes as well as for high-dimensional integration. Exact values and strong lower bounds for the so-called k-error linear complexity of some particular interesting binary sequences were proven. Also, a combination of the concepts of explicit and recursive nonlinear pseudorandom number generators, leading to the so-called counter-dependent generator, was introduced and analyzed. A new lattice test for nonlinear pseudorandom number generators was introduced which is much stronger than all its predecessors. Finally, the work on quantum period finding algorithms, started in collaboration with the Symbolic Computation group, was continued. It was shown that a quantum algorithm of Hales and Hallgren can be used to determine the period of a sequence over a finite field if only a few most significant bits of some sequence elements are known.

In 2007, altogether 45 publications of group members appeared or were accepted for publication in journals and refereed conference proceedings and about 25 additional manuscripts are currently submitted for publication. In this period, group members gave 17 invited and 18 contributed talks at international conferences. In addition, 18 invited colloquia and seminar talks at universities and research institutes were delivered, in several cases connected with a research stay at the corresponding institution. In Linz, the group hosted 4 long-term and about 15 international short-term visitors.
In May 2007, an “International Workshop on Financial and Actuarial Mathematics for Young Researchers” with about 50 participants from all over Europe and Canada was organized by H. Albrecher and P. Mayer (Graz) at RICAM, providing young PostDocs and PhD students the

opportunity to exchange research ideas and to get to know the institute. This workshop was well received by both the participants and the local scientists.

The Financial Mathematics Group has several fruitful on-going collaborations with other research groups at RICAM, for instance with the Inverse Problems Group (calibration techniques for local Levy models), with the Optimisation and Control Group (computation of boundaries of trading regions with transaction costs for finite time horizon) and with the Symbolic Computation Group (symbolic computation for boundary problems in risk theory). Details on these and further collaborations can be found in the reports of the individual researchers.

From September to December 2008, a Special Semester on Stochastics with particular emphasis on Mathematical Finance will take place at RICAM. Various internationally renowned scientists have already confirmed their participation and it is to be expected that the corresponding scientific activities and events will have a stimulating impact on many of the above research activities of our group, too. In particular, the Special Semester activities will provide an excellent opportunity to trigger further collaboration between the RICAM research groups.

Univ.-Prof. Dr. Hansjörg Albrecher

Scientific Achievements 2007

Apart from conducting and participating in research activities within the Financial Mathematics group and collaborations between RICAM groups (described at other places in this report), H. Albrecher continued his work in collective risk theory and the interplay between finance and insurance.
Dividend strategies in insurance portfolios and their optimality in various contexts were investigated in [3,4,5,7] in joint work with J. Hartinger and S. Thonhauser.
Due to new taxation rules for equalization reserves and increasingly tight regulations for the estimation of IBNR and RBNS reserves, the issue of tax payments in insurance portfolios is becoming more prominent in practice. For the classical collective risk model it was established in [6] in joint work with C. Hipp that tax payments according to a loss carried forward system have a surprisingly transparent effect on solvency probabilities of the insurance activities and that, moreover, optimal taxation rules can be determined. A generalization of this result to general spectrally negative Levy processes was then established with J. Renaud and X. Zhou in [16] and to dual risk models with A. Badescu and D. Landriault in [15]. Interpretations of this tax identity from a queueing perspective are currently being addressed with O. Boxma (Eindhoven).
In a collaboration with the Inverse Problems Group, we succeeded to establish convergence rates for a certain suitably regularized procedure to robustly calibrate local Levy models to prices of liquid vanilla options in the
market (see [9]); a corresponding study in a more general framework is in progress.
In [12], together with J. Teugels (Leuven), a unified approach to the analysis of the number of claims and the aggregate claim sizes in excess-of-loss reinsurance contracts based upon the use of point processes was developed.
Parts of the above research activities were carried out via the FWF research project P18392 “Mathematical Models for Insurance Risk” led by H. Albrecher. He is currently supervising four Master theses and five PhD theses (S. Haas, D. Kortschak, P. Mayer, P. Ngare and S. Thonhauser). In Spring 2007 he was external examiner at PhD defences in Leuven (Belgium) and Trier (Germany). In July 2007, he gave a 2-days-Workshop on “Dependence in Collective Risk Theory” in Piraeus with about 40 participants, preceding the IME congress. He also continued to work on his book project on Reinsurance with J. Teugels (at Wiley) and on the textbook on Financial Mathematics for Bachelor studies together with A. Binder (at Birkhaeuser).

Since January 2007, H. Albrecher is Associate Editor of the journals "Mathematical Methods of Operations Research" and "Blätter der deutschen Gesellschaft für Versicherungs- und Finanzmathematik".

Scientific Cooperations

Internal

In addition to cooperations within the Financial Mathematics group and the FWF project P18392, also with:
Dr. S. Kindermann and Prof. H. Engl: Inverse problems for local Levy models
Dr. G. Regensburger and Dr. M. Rosenkranz: Symbolic computation for boundary problems in risk theory

External
Prof. S. Asmussen (University of Aarhus): Dependence in Risk Theory
Dr. A. Badescu (University of Toronto): Dependence in Risk Theory
Prof. O. Boxma (TU Eindhoven): Ruin Models with Dependency
Dr. M. Claramunt (Universitat de Barcelona): Dividend barrier models
Prof. K. Eisele (Universite Louis Pasteur Strasbourg): Multivariate Phase-Type Distributions
Dr. Manuel Guerra (Lisbon): Optimality of Reinsurance Contracts
Prof. C. Hipp (University of Karlsruhe): Risk processes with tax and heavy tails
Prof. R. Korn (Kaiserslautern): Stochastic control in finance
Dr. D. Landriault (University of Waterloo): Risk Theory
Dr. C. Macci (University Tor Vergada, Rome): Large deviation techniques
Prof. W. Schoutens (K.U. Leuven): Hedging of Exotic Options
Prof. J. Teugels (K.U. Leuven): Actuarial Aspects of Reinsurance
Prof. R. Tichy (TU Graz): QMC Techniques in Risk Theory
Dr. D. Vyncke (University of Gent): Simulation Techniques
Prof. G. Wilmott (University of Waterloo): Discounted Penalty Functions
Prof. H. Yang (University of Hong Kong): Ruin theory in an economic environment
Dr. X. Zhou (Concordia University, Montreal): Levy processes in risk theory

Research Visits, Conferences and Talks

Versicherungsmathematisches Kolloquium, University of Cologne, January 29-30:
Invited Talk: "Ruin theory in the presence of dividend and tax payments"

Department of Mathematics, University of Trier, March 5-6:
Invited Talk: „Optimale Dividenden- und Besteuerungs-Strategien in der kollektiven Risikotheorie"

Department of Mathematics, K.U. Leuven and EURANDOM, Eindhoven, March 14-16:
Invited Talk: „Ruin theory in the presence of dividend and tax payments"

Workshop on Integrated Risk Management, Tilburg, Netherlands, April 10-13:
Invited Talk: „ Efficient Valuation of Securitization Products"

IQPC Conference on Correlation Trading, London, April 24-27:
Invited Talk: „ A Generic Levy Model for Pricing Synthetic Collateralized Debt Obligations"

Organization of the Radon Workshop on Financial and Actuarial Mathematics for Young Researchers (FAYR 07), jointly with P. Mayer, at the RICAM in Linz, May 30-31

Organization of a "Colloquium on Actuarial and Financial Mathematics: Theory and Practice" at Graz University of Technology, jointly with Prof. R. Tichy, June 1

Department of Mathematics, University of Innsbruck, June 21:
Invited Talk: "Stochastische Modelle für Versicherungsrisiken"

11th Congress on Insurance: Mathematics & Economics, Piraeus, Greece, July 7-12:
Invited Lecture Series (8 hours): "Dependence in Collective Risk Theory"
Contributed Conference Talk: "Lundberg's risk process with tax"

Co-Organization of a Mini-Symposium at the ICIAM 07 in Zurich, July 20 (jointly with Dr. E. Resmerita from the Inverse Problems Group): „Bregman distances with Applications in Inverse Problems, Optimization and Finance"

Austrian Academy of Sciences, Vienna, September 18:
Invited Talk: "Versicherungsmathematik am Radon-Institut"

Workshop of the German Academy of Actuaries, Günzburg, September 21-22:
Invited Talk: "Abhängige Risiken und Ruintheorie "

Quant Congress Europe, London, November 14-15

Autumn Conference of the German Association of Actuaries, Munich, November 18-20:
Invited Talk: "Approximationen fuer Gesamtschadenverteilungen und Ruinwahrscheinlichkeiten im subexponentiellen Fall"

37e Journee de Seminaires Actuariels, Lausanne, November 26:
Invited Talk: "Dividend and Tax Payments in Risk Theory"

Int. Workshop on Multivariate Risk Management, EURANDOM, Eindhoven, December 10-11:
Invited Talk: "Tax Payments in Risk Theory"

Lectures:
1. Advanced Insurance Mathematics, Winter 2006/7 (TU Graz)
2. Mathematics for Finance and Insurance 1, Summer 2007 (TU Graz)
3. Seminar Financial Mathematics, Winter 2006/7 (JKU Linz)
4. Mathematics for Finance and Insurance 1, Winter 2007/08 (TU Graz)

Publications 2007

Appeared
1. H. Albrecher, P. Mayer, W. Schoutens, J.Tistaert, The little Heston trap, WILMOTT, No.1, 83-92.
2. H. Albrecher, S. Ladoucette, W. Schoutens, A generic one-factor Levy model for pricing synthetic CDOs. In: Advances in Mathematical Finance, M. Fu, R. Jarrow, J. Yen, R.J. Elliott (eds.), pp. 259-278, Birkhäuser, Boston.
3. H. Albrecher, S. Thonhauser, Discussion of "On the merger of two companies", North American Actuarial Journal 11(2), 157-159.
4. S. Thonhauser, H. Albrecher, Dividend maximization under consideration of the time value of ruin, Insurance: Mathematics & Economics 41 (1), 163-184.
5. H. Albrecher, J. Hartinger, A risk model with multi-layer dividend strategy, North American Actuarial Journal 11(2), 43-64.

5a. Author's Reply to Discussions of the Paper: North American Actuarial Journal 11 (4), to appear.

6. H. Albrecher, C. Hipp, Lundberg's risk process with tax, Blätter der DGVFM 28 (1), 13-28.

7. H. Albrecher, J. Hartinger, S. Thonhauser, Exact solutions for dividend strategies of threshold and linear barrier type in a Sparre Andersen model, ASTIN Bulletin 37 (2), 203-233.

Accepted
8. H. Albrecher, P. Mayer, W. Schoutens, General lower bounds for arithmetic Asian option prices, Applied Mathematical Finance, to appear.
9. S. Kindermann, P. Mayer, H. Albrecher, H. Engl: Identification of the local speed function in a Levy model for option pricing, Journal of Integral Equations and Applications, to appear.
10. D. Kortschak, H. Albrecher, Asymptotic results for the sum of dependent non-identically distributed random variables, Methodology and Computing in Applied Probability, to appear.
11. H. Albrecher, The next step: CDO's for catastrophe risks, WILMOTT, to appear.

Submitted
12. H. Albrecher, S. Ladoucette, J. Teugels, Asymptotics of the Sample Coefficient of Variation and the Sample Dispersion.
13. H. Albrecher, J. Teugels, On Excess-of-Loss Reinsurance, EURANDOM Report 2007-17.
14. H. Albrecher, S. Thonhauser: Optimal dividend strategies for a risk process under force of interest.
15. H. Albrecher, A. Badescu, D. Landriault: On the dual risk model with taxation.
16. H. Albrecher, J. Renaud, X. Zhou: A Levy insurance risk process with tax. RICAM Report 2007-34.

Dominik Kortschak advised by Prof. Hansjörg Albrecher

Scientific Achievements 2007

In 2007 the work of DI Kortschak was focused on two topics. At first he continued his work on the asymptotic probability that the sum of dependent non-identically distributed random variables is higher than a given threshold, leading to [3]. Here the main focus was on subexponential marginal distributions. Such problems arise for instance in financial mathematics when one wants to evaluate the probability of high losses of portfolios.
The second topic on which DI Kortschak was working is the evaluation and asymptotic expansion of ruin probabilities in the Cramer-Lundberg model with subexponential claim size distributions, a classical topic in risk theory that still lacks a complete treatment up to date. In particular, he could generalise an available integral representation for the ruin probability with US Pareto claim size distribution with integer parameter to the case of arbitrary parameters. Further he used this representation to derive an asymptotic expansion for the ruin probability. He also derived an asymptotic expansion for the ruin probability in the case of the classical Pareto claim size distribution and generalized this to special compound distributions.

Scientific Cooperations

Internal
Prof. H. Albrecher

External
Prof. S. Asmussen (University of Aarhus): Heavy-tailed dependent sums
Prof. C. Hipp (University of Karlsruhe (TH)): Asymptotic expansions

Participation at Conferences, Scientific Visits and Talks

Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, May 30-31

5th Conference on Extreme Value Analysis Probabilistic and Statistical Models and their Applications, Bern, Switzerland, July 23 – 27, 2007
Poster Session: "Asymptotic results for the sum of dependent non-identically distributed random variables"

Workshop für junge Mathematiker/Mathematikerinnen, Reisensburg, Günzburg bei Ulm, 21. und 22. September 2007

Publications 2007

Accepted
[1] D. Kortschak and H. Albrecher, Asymptotic results for the sum of dependent non-identically distributed random variables, Methodology and Computing in Applied Probability, to appear.

Submitted
[2] J. Hartinger and D. Kortschak, Quasi-Monte Carlo techniques and rare event sampling, RICAM Report 26-05.
[3] J. Hartinger and D. Kortschak, On the efficiency of the Asmussen-Kroese-estimator and its application to stop-loss transforms.

Philip Ngare advised by Prof. Hansjörg Albrecher

Scientific Achievements 2007

DI Ngare graduated from the University of Nairobi and started his PhD studies at RICAM in March 2007. He is financed through a scholarship of the Austrian Exchange Service. During the first months of his stay he made himself acquainted with theoretical and practical issues of mathematical finance and then started with original research in the field of securitization of natural catastrophe risk with particular focus on problems that are faced in Kenia in this context.

Conferences

Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, May 30-31

Stefan Thonhauser advised by Prof. Hansjörg Albrecher

Scientific Achievements 2007

In the first part of the year 2007 the work of DI Stefan Thonhauser was concentrated on a dividend maximization problem for a classical risk process with a constant force of interest acting on the free reserve. It was possible to extend classical stochastic control results to this more realistic setting. Furthermore a cooperation with Dr. Löpker (EURANDOM) was initiated. The main goal of this collaboration is to develop suitable tools for investigating time-dependent dividend strategies with varying degree of generality in the Sparre Andersen risk model, applying techniques from Piecewise Deterministic Markov Process (PDMP) theory.

Scientific Cooperations

Internal
Cooperation with Prof. H. Albrecher and Dr. C. Constantinescu

External
Cooperation with Dr. A. Löpker (EURANDOM Eindhoven)

Participation at Conferences, Scientific Visits and Talks

- Seminar za verjetnost in statistiko at University of Ljubljana, Ljubljana, Slovenia, 02.03.2007, Invited Talk: Dividend maximization under consideration of the time value of ruin.

- Third Brazilian Conference on Statistical Modelling in Insurance and Finance, Maresias, Brazil, 25.03.2007 - 30.03.2007,
  Talk: Dividend maximization under consideration of the time value of ruin.

- Workshop on Mathematical Control Theory and Finance, Lisbon, Portugal, 10.04.2007 - 14.04.2007,
  Talk: Dividend maximization under consideration of the time value of ruin.

- Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, 30.05.2007-31.05.2007

- Talk at the Radon Group Seminar, Linz, Austria, 06.07.2007: Optimal dividend strategies for a risk process under force of interest.

- Workshop “Dependence in Collective Risk Theory”, Piraeus, Greece, 08.07.2007-09.07.2007.

- 11th Congress on Insurance: Mathematics and Economics 2007, Piraeus, Greece, 10.07.2007 - 12.07.2007,
  Talk: Optimal dividend strategies for a risk process under force of interest.

- AMaMeF 2007, Vienna, Austria, 17.09.07-22.09.07, September 2007,
  Talk: Optimal dividend strategies for a risk process under force of interest.

- Eurandom, SOR/QPA Seminar, 11.10.07, October 2007,
  Invited Talk: Optimal dividend strategies for a risk process under force of interest.

Publications 2007

Appeared:
1. H. Albrecher, S. Thonhauser, Discussion of ``On the Merger of Two Companies'', North American Actuarial Journal, 11(2):157-159, 2007
2. S. Thonhauser, H. Albrecher, Dividend maximization under consideration of the time value of ruin, Insurance: Mathematics & Economics 41:163-184, 2007.
3. H. Albrecher, J. Hartinger, S. Thonhauser, Exact solutions for dividend strategies of threshold and linear barrier type in a Sparre Andersen model, ASTIN Bulletin, 37(2):203-233, 2007.

Submitted:
4. H. Albrecher, S.Thonhauser, Optimal dividend strategies for a risk process under force of interest. RICAM Research Report 2007-20.

Prof. Walter Schachermayer

Research Visits, Conferences and Talks

Pauli Symposium on PDEs in Mathematical Finance & Economy, WPI, Vienna, Austria; 23.11.2007
Invited Talk: "How agents with different attitudes towards risk optimize their portfolio: old and new results"

FAM-Seminar, TU Wien, Austria; 13.11.2007
Talk: "In which Financial Markets do Mutual Fund Theorems hold true?"

Seminar for Financial and Insurance Mathematics, ETH Zürich, Switzerland; 15.10.2007
Invited Talk:"In which Financial Markets does the Mutual Fund Theorem hold true?"

Workshop on optimal transportation structures, gradient flows and entropy methods for applied PDE's, WPI, Vienna, Austria, 26.09.2007
Invited Talk: "Optimal and better transport plans"

Conference on Stochastic Programming (SPXI), University Vienna, Austria; 31.08.2007
Invited Talk: "Optimal Risk Sharing for Law Invariant Monetary Utility Functions"

Session of the International Statistical Institute (ISI), Lissabon, Portugal; 24.08.2007
Invited Talk: "Optimal Risk Sharing for Law Invariant Monetary Utility Functions"

Conference on Further Developments in Quantitative Finance, ICMS Edinburgh, UK; 12.07.2007
Invited Talk: "Consistent Price Systems and Face-Lifting Pricing under Transaction Costs"

Colloquium in Honor of Hans Föllmer, Humboldt University, Berlin, Germany; 09.06.2007
Invited Talk: "Asymptotic arbitrage and large deviations "

Fourth General Meeting of the French Applied Math Society (SMAI), Praz sur Arly, France, 05.06.2007.
Invited Talk: "Finance and Stochastics - A Mutually Fruitful Relationship"

Computer and Automation Institute, Hungarian Academy of Science, Budapest, Hungary, 21.05.2007.
Invited Course: "Arbitrage theory and transaction costs - Semi-Martingales and beyond";

Feierstunde zu Ehren von Prof.Dr. Franz Alt, Vienna University, Austria, 10.05.2007.
Invited Talk: "Über die Messbarkeit des Nutzens"

Jahrestagung DMV und GDM 2007, Humbold Universität zu Berlin, Germany, 26.03.2007.
Invited Talk: "Finance and Stochastics - A Mutually Fruitful Relationship"

Research Seminar in Economic Theory, University of Vienna, Austria, 15.03.2007
Invited Talk: "Optimal Risk Sharing for Law Invariant Monetary Utility Functions"

Publications 2007

Appeared
[1] P. Grandits, F. Hubalek, W. Schachermayer, M. Zigo: Optimal Expected Exponential Utility of Dividend Payments in Brownian Risk Model, Scandinavian Actuarial Journal, No.2, 73-107 (2007)

[2] W. Schachermayer, J. Teichmann: Wie K. Itô den stochastischen Kalkül revolutionierte, Internationale Mathematische Nachrichten, 205 (2007), 11 - 22.

Accepted

[3] W. Schachermayer, J. Teichmann: How close are the Option Pricing Formulas of Bachelier and Black-Merton-Scholes? Mathematical Finance, to appear.
[4] E. Jouini, W. Schachermayer, N. Touzi: Optimal risk sharing for law invariant monetary utility functions, Mathematical Finance, to appear.
[5] W. Schachermayer, J. Teichmann: Characterization of optimal Transport Plans for the Monge-Kantorovich-Problem, Proceedings of the A.M.S, to appear.
[6] P. Guasoni, M. Rásonyi, W. Schachermayer: Consistent Price Systems and Face-Lifting Pricing under Transaction Costs, Annals of Applied Probability, to appear.

Submitted

[7] W. Schachermayer, U. Schmock, J. Teichmann: Non-monotone convergence in the quadratic Wasserstein distance.
[8] P. Guasoni, M. Rásonyi, W. Schachermayer: The Fundamental Theorem of Asset Pricing for Continuous Processes under Small Transaction Costs.
[9] H. Föllmer, W. Schachermayer: Asymptotic Arbitrage and Large Deviations.
[10] W. Schachermayer, M. Sirbu, E. Taflin: In which Financial Markets do Mutual Fund Theorems hold true?

Dr. Corina Constantinescu

Scientific Achievements 2007

In 2007, Dr. Constantinescu continued her research on the interplay between financial and actuarial mathematics. In a joint work with E. Thomann [2] she extended some results from her PhD dissertation regarding generators for jump diffusion processes with jumps at renewal times. Namely, the generator obtained initially for the collective Sparre Andersen models with risky investments was generalized to an arbitrary renewal jump diffusion process with general diffusions and one-sided jumps.

In a joint work with H. Albrecher and E. Thomann [3] she extended the asymptotic analysis of investment strategies in insurance. Specifically, the asymptotic behavior of the probabilities of ruin in the case of generalized Erlang inter-arrival times is investigated when the insurance company undertakes risky investments, for both light and heavy-tailed claim size distributions.

The 2007 paper of H. Albrecher and C. Hipp introducing taxes in the classical Lundberg risk model set the stage for many possible extensions. C. Constantinescu focused on the analysis of the impact of taxes on ruin probabilities in renewal settings. When the risk process is assumed to be based on a delayed renewal processes, the survival probabilities satisfy high-order partial integro-differential equations with correspondingly many boundary conditions. The striking result from the aforementioned paper can be retrieved through this differential equations approach. However, for the general renewal case, the derivation of the appropriate boundary conditions and furthermore of the closed form solutions of high-order PDEs turn out to be a delicate and challenging problem (still in progress).

Boundary value problems for functions relevant in risk theory (and in particular for the models with taxes) ignited a fruitful cooperation between the Financial Mathematics Group (C. Constantinescu and H. Albrecher) and the Symbolic Computation Group (M. Rosenkranz and G. Regensburger). Through symbolic computation methods exact solution formulae for expected discounted penalty functions (Gerber-Shiu functions) could be derived in a general renewal setting, for generic penalty functions. This method circumvents the traditional Laplace transform approach and can be applied under weaker analyticity conditions on the involved quantities.

Together with M. Rosenkranz and G. Regensburger, C. Constantinescu submitted a research proposal on the "Symbolic Computation Approach to Gerber-Shiu Functions" that already qualified for the final round of the 2008 Individual Grant Competition (organized by The Actuarial Foundation's AERF Committee, Casualty Actuarial Society and Society of Actuaries' CKER).

Participation at Conferences, Scientific Visits and Talks

- Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, May 30-31
- Research Visit at the Mathematics Department of Oregon State University, Corvallis, OR, June 18-22
- Talk at the Radon Group Seminar, Linz, Austria, July 6: "Asymptotic results for the ruin probability in Sparre Andersen models with risky investments"
- Workshop "Dependence in Collective Risk Theory", University of Piraeus, Piraeus, Greece, July 8-9
- 11th International Congress on Insurance Mathematics and Economics, Piraeus, Greece, July 10-12
  Talk: "Asymptotic results for the ruin probability in Sparre Andersen models with risky investments"

Scientific Cooperations

Internal
H. Albrecher (Financial Mathematics)
G. Pirsic (Financial Mathematics)
S. Thonhauser (Financial Mathematics)
G. Regensburger (Symbolic Computation)
M. Rosenkranz (Symbolic Computation)

External
E. Thomann (Oregon State University)
E. Waymire (Oregon State University)

Publications 2007

1. C. Constantinescu, E. Thomann. An Integro-differential Equation for a Sparre Andersen Model with Investments. Proceedings 41st Actuarial Research Conference, Montreal, Canada, 2006. Actuarial Research Clearing House ARCH, 2007.1, January 2007
2. C. Constantinescu, E. Thomann. On the generator of Renewal Jump Diffusion Processes, Preprint.
3. H. Albrecher, C. Constantinescu, E. Thomann. Asymptotic analysis of ruin probabilities in Sparre Andersen models with risky investments, Preprint.

Dr. Markus Hahn

Scientific Achievements 2007

After finishing his PhD in December 2006, in 2007 Dr Hahn mainly worked on calibration of continuous-time stock models using Markov chain Monte Carlo methods; in particular, he studied Markov switching models and models with Gaussian drift. In cooperation with Prof Frühwirth-Schnatter, DI Putschögl, and Dr Sass, he developed different estimation algorithms, focussing on applications to financial time series.

Scientific Cooperation

Internal
With DI Putschögl and Dr Sass within the FWF project.

External
With Prof. Frühwirth-Schnatter, IFAS, JKU Linz, on MCMC methods for Markov switching models.

Participation at Conferences, Scientific Visits and Talks

Conferences (including talks and posters)

Computational and Financial Econometrics 2007, Geneva, Switzerland, April 20-22,
Talk: "MCMC Methods for Parameter Estimation in Multidimensional Continuous Time Markov Switching Models"

Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, May 30-31

BISP5, Valencia, Spain, June 14-16,
Poster: "MCMC estimation of Markov switching models"

Österreichische Statistiktage 2007, Linz, Austria, September 18-20,
Talk: "Semi-continuous MCMC estimation of continuous time Markov switching models"

Lectures

Financial Mathematics project at "Applied mathematics week" for intellectually gifted high school pupils organised by "Stiftung Talente", February 11-15.

Publications 2007

Appeared
1. M. Hahn, W. Putschögl, J. Sass, Parameter estimation for stock models with non-constant volatility using Markov chain Monte Carlo Methods. In K.-H. Waldmann, U.M. Stocker (eds.): Operations Research Proceedings 2006, Springer, Berlin, 227-232.
2. M. Hahn, W. Putschögl, J. Sass, Portfolio optimization with non-constant volatility and partial information, Brazilian Journal of Probability and Statistics 21, 27-61.

Accepted
3. M. Hahn, W. Putschögl, J. Sass: Optimizing consumption and investment: The case of partial information. Operations Research Proceedings 2007, to appear, Springer, Berlin, 2007

Submitted

4. M. Hahn, S. Frühwirth-Schnatter, J. Sass: Markov chain Monte Carlo Methods for parameter estimation in multidimensional continuous time Markov switching models (RICAM Report 2007-09).
5. M. Hahn, S. Frühwirth-Schnatter, J. Sass: Estimating Markov processes based on merged time series.
6. M. Hahn, J. Sass: Parameter estimation in continuous-time Markov switching models - A semi-continuous Markov chain Monte Carlo approach.

Dr. Jean-François Renaud

Scientific Achievements 2007 (since joining RICAM)

Recently, Albrecher and Hipp (2007) introduced taxes in the classical Cramér-Lundberg risk model. Their results have a very transparent structure and are easy to employ in practice. After joining the group in August 2007, Dr. Renaud worked on an extension of these tax results to a general spectrally negative Lévy insurance risk model. The results of Albrecher and Hipp (2007) were established in this more general setup and, moreover, a solution to the two-sided exit problem for this Lévy risk process with tax was obtained. Also, moments of all orders of the discounted tax payments during the lifetime of the process were computed. This work resulted in [2]. In this paper, various connections with the results in [4] are identified.
Dr. Renaud also worked on a discrete-time approximation scheme for nonnegative diffusion processes. The scheme uses Markov chains and relies on the so-called martingale problem of Stroock and Varadhan; see [1].
In addition, Dr. Renaud extracted some results from his PhD Thesis and submitted an article concerned with an extension of Malliavin calculus to Lévy processes; see [3].

Participation at Conferences, Scientific Visits and Talks

Conferences

- Workshop and Mid-Term Conference on Advanced Mathematical Methods for Finance (A.Ma.Me.F.), Vienna University of Technology, Austria, September 17-22, 2007
- 5th International Conference on Lévy Processes: Theory and Applications, University of Copenhagen, Denmark, August 13-17, 2007.
- Satellite Summerschool on Lévy Processes: Theory and Applications, Sandbjerg Manor, Denmark, August 9-12, 2007.

Talks

- Swiss Probability Seminar, Universität Bern, Switzerland, December 5, 2007
  Invited Talk: “Spectrally negative Lévy risk processes with dividends and with tax”
- Radon Group Seminar, Linz, Austria, November 30, 2007
  Talk: “Spectrally negative Lévy risk processes with dividends and with tax”

Scientific Cooperations

Internal
H. Albrecher (Financial Mathematics)
S. Thonhauser (Financial Mathematics)

External
R. Korn (Universität Kaiserslautern)
A. Kyprianou (University of Bath)
B. Rémillard (HEC Montréal)
X. Zhou (Concordia University, Montréal)

Publications 2007

[1] J.-F. Renaud and X. Zhou. Distribution of the present value of dividend payments in a Lévy risk model, Journal of Applied Probability, vol. 44, no. 2, 2007.
[2] J.-F. Renaud and B. Rémillard. Explicit martingale representations for Brownian functionals and applications. Stochastic Analysis and Applications, vol. 25, no. 4, 2007.
[3] H. Albrecher, J.-F. Renaud and X. Zhou. A Lévy insurance risk process with tax, RICAM Report 2007-34, submitted
[4] J.-F. Renaud and B. Rémillard. Malliavin calculus and Clark-Ocone formula for functionals of a square-integrable Lévy process, submitted
[5] B. Rémillard and J.-F. Renaud. Weak approximations of nonnegative diffusion processes, Working paper.

Dr. Jörn Sass

Scientific Achievements 2007

In 2007 Dr Sass continued his work on portfolio optimization and on parameter estimation in Markov switching models. In [8] the utility maximization problem under a shortfall risk constraint is solved and strategies are derived, in [2, 5] the results are applied to a hidden Markov model for the drift of the stock returns. This is a model with partial information where the underlying drift process has to be filtered from the observations. In [6] models with unobservable drift and non-constant volatility models (e.g. Hobson-Rogers-model) are considered and a Markov chain Monte Carlo (MCMC) method to estimate the relevant parameters is derived, generalized in [4]. Optimal consumption under quite general conditions on the drift is considered in [7, 12]. Further [1] deals with convex constraints on the trading strategies (including the case of stochastic volatility models) which lead to an incomplete market. This is partly joint work with Dr Hahn and DI Putschögl in the FWF project P17947-N12, led by Dr Sass. Another part of the project includes parameter estimation in Markov switching models. In [8] a method of moments combined with a linear regression is used to estimate parameters, providing very good estimates for large sample sizes. For less observations and critical parameter ranges MCMC methods in [10, 11, 13] can improve the widely used expectation maximization algorithm. Further improvements are discussed with the Inverse Problems Group.

Scientific Cooperation

Internal (name, topic, publication(s))
M. Hahn, parameter estimation in Markov switching models, [4, 6, 10, 11, 13], continued.
R. Griesse, K. Kunisch, numerical solution of free boundary problems arising in finance, [3] continued.
W. Putschögl, portfolio optimization under partial information, [4, 6, 7, 12], continued.
E. Resmerita, EM algorithm for infinite dimensional filters, discussed.
W. Schachermayer, shadow price processes in models with transaction costs, discussed.

External (name, affiliation, topic, publication(s))
R.J. Elliott, University of Calgary, method of moments for Markov switching models, [8].

S. Frühwirth-Schnatter, JKU Linz, MCMC methods for Markov switching models, [10, 11], continued.
A. Gabih, Universität Leipzig, utility maximization under risk constraints, [2, 9], continued.
U.G. Haussmann, UBC Vancouver, portfolio optimization with partial information, Lévy noise, advanced.
A. Irle, C. Prelle, Universität Kiel, portfolio optimization under transaction costs, continued.
V. Krishnamurthy, UBC Vancouver, method of moments for Markov switching models, [8].
M. Schäl, Universität Bonn, numeraire portfolio under transaction costs, advanced.
R. Wunderlich, FH Zwickau, utility maximization under risk constraints, [2, 5, 9], continued.

Participation at Conferences, Scientific Visits and Talks

Conferences

Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, May 30-31.

Computational Methods in Finance, Waterloo, Canada, July 26/27,
Talk: Trading regions for portfolio optimization under transaction costs.

Workshop and Mid-Term Conference on Advanced Mathematical Methods for Finance, Vienna, Austria, September 17-22,
Talk: The numeraire portfolio under transaction costs

Scientific Visits and Talks

PIMS-MITACS Mathematical Finance Seminar, UBC, Vancouver, Canada, January 17,
Invited Talk: The numeraire portfolio under transaction costs.

Mathematics Department, UBC, Vancouver, Canada, January 14-22,
Invited Talk: Optimal portfolio policies under transaction costs.

Fachbereich Mathematik: Universität Siegen, Siegen, Germany, February 21,
Invited Talk: Optimale Handelsstrategien bei Transaktionskosten.

Institut für Angewandte Mathematik, Universität Bonn, Germany, Februar 22.

Fachbereich Mathematik, Universität Kaiserslautern, Germany, May 9,
Invited Talk: Die optimale Wachstumsrate bei Transaktionskosten.

Mathematisches Seminar, Universität Kiel, August 13-16.

Fakultät für Mathematik, TU Chemnitz, Germany, October 2,
Invited Talk: Maximierung der Wachstumsrate unter Transaktionskosten.

Department of Mathematical Sciences, Aarhus University, December 13,
Invited Talk: Trading regions for portfolio optimization under transaction costs

Guests

Prof. R. Wunderlich, University of Applied Sciences Zwickau, March 12-16, December 6-8.
Dr C. Prelle, University of Kiel, June 1-4.

Lectures

Schadenversicherungsmathematik (non-life insurance, risk theory), winter 2006/7, JKU Linz.
Stochastic control theory with applications to financial mathematics, summer 2007, JKU Linz.

Publications 2007

Appeared

[1] J. Sass: Utility maximization with convex constraints and partial information. Acta Applicandae Mathematicae 97, 221-238.
[2] R. Wunderlich, J. Sass, A. Gabih: Optimal portfolios under bounded shortfall risk and partial information. In K.-H. Waldmann, U.M. Stocker (eds.): Operations Research Proceedings 2006, Springer, Berlin, 581-586.
[3] K. Kunisch, J. Sass, Trading regions under proportional transaction costs. In K.-H. Waldmann, U.M. Stocker (eds.): Operations Research Proceedings 2006, Springer, Berlin, 563-568.
[4] M. Hahn, W. Putschögl, J. Sass, Parameter estimation for stock models with non-constant volatility using Markov chain Monte Carlo Methods. In K.-H. Waldmann, U.M. Stocker (eds.): Operations Research Proceedings 2006, Springer, Berlin, 227-232.
[5] J. Sass, R. Wunderlich: Computing optimal portfolio policies with unobservable Markov modulated drift process and bounded expected loss. In C. Fernandes, H. Schmidli, N. Kolev (eds.): Third Brazilian Conference on Statistical Modelling in Insurance and Finance, IME, Sao Paulo, 242-247.
[6] M. Hahn, W. Putschögl, J. Sass, Portfolio optimization with non-constant volatility and partial information, Brazilian Journal of Probability and Statistics 21, 27-61.

Accepted

[7] M. Hahn, W. Putschögl, J. Sass: Optimizing consumption and investment: The case of partial information, to appear in Operations Research Proceedings 2007, Springer, Berlin.

Submitted

[8] R.J. Elliott, V. Krishnamurthy, J. Sass, Moment based regression algorithm for drift and volatility estimation in continuous time Markov switching models, revised version.
[9] A. Gabih, J. Sass, R. Wunderlich, Utility maximization under bounded expected loss.
[10] M. Hahn, S. Frühwirth-Schnatter, J. Sass: Markov chain Monte Carlo Methods for parameter estimation in multidimensional continuous time Markov switching models (RICAM Report 2007-09).
[11] S. Frühwirth-Schnatter, M. Hahn, J. Sass: Estimating Markov processes based on merged time series.
[12] W. Putschögl, J.Sass, Optimal consumption and investment under partial information.
[13] M. Hahn, J. Sass: Parameter estimation in continuous-time Markov switching models - A semi-continuous Markov chain Monte Carlo approach

Dr. Wolfgang Putschögl advised by Dr. Jörn Sass

Scientific Achievements 2007

In 2007 the work of Dr Putschögl was focused on portfolio optimization under partial information. In [2] explicit representations of the optimal trading strategy using Malliavin calculus have been derived in a hidden Markov model for the drift and non-constant volatility; [3] deals with the parameter estimation for this model. Further optimal consumption strategies have been considered under partial

information and explicit consumption and investment strategies are derived under fairly general conditions in [4] and [5]. The current work involves dynamic risk constraints for portfolio optimization under partial information. He finished his Ph.D. studies in December 2007, [1].

Scientific Cooperation

Cooperation with Dr Hahn and Dr Sass within the FWF project.

Participation at Conferences, Scientific Visits and Talks

Conferences (including talks)

Radon Workshop on Financial and Actuarial Mathematics for Young Researchers, RICAM, Linz, Austria, 30.05.2007-31.05.2007

22nd European Conference on Operational Research, Prague, Czech Republic, 22nd European Conference on Operational Research, Prague, Czech Republic, 08.07.07-11.07.07
Talk: Optimal consumption and investment under partial information.

Operations Research 2007, Saarbrücken, Germany, 05.09.07-07.09.07
Talk: Optimal Consumption and Investment under Partial Information

Workshop and Mid-Term Conference on Advanced Mathematical Methods for Finance, Vienna, Austria, 17.09.07-22.09.07
Talk: Optimal Investment Under Dynamic Risk Constraints and Partial Information

Lectures

- Lecture Financial mathematics (assistant of Dr. Leobacher), winter 2007, JKU Linz
- Lecture Financial mathematics and statistics 1, winter 2007, University of Applied Sciences Linz
- Lecture Financial mathematics and statistics 2, summer 2007, University of Applied Sciences Linz
- Lecture Stochastic financial mathematics (assistant of Prof. Larcher), summer 2007, JKU Linz
- Financial Mathematics project at "Applied mathematics week" for intellectually gifted high school pupils organised by "Stiftung Talente", February 11-15.

Publications 2007

Ph.D. thesis

[1] Portfolio Optimization under Partial Information, Johanes Kepler Universität, Linz, 2007.

Appeared
[2] M. Hahn, W. Putschögl, J. Sass, Portfolio optimization with non-constant volatility and partial information, Brazilian Journal of Probability and Statistics 21, 27-61.
[3] M. Hahn, W. Putschögl, J. Sass, Parameter estimation for stock models with non-constant volatility using Markov chain Monte Carlo Methods. In K.-H. Waldmann, U.M. Stocker (eds.): Operations Research Proceedings 2006, Springer, Berlin, 227-232.

Accepted
[4] M. Hahn, W. Putschögl, J. Sass: Optimizing consumption and investment: The case of partial information, to appear in Operations Research Proceedings 2007, Springer, Berlin

Submitted
[5] W. Putschögl, J.Sass, Optimal consumption and investment under partial information.

Dr. Klaus Scheicher

Scientific Achievements 2007

In 2007, Dr. Scheicher continued his studies of applications of quasi-Monte Carlo algorithms in ruin theory. In the most simple case of the compound Poisson model, the survival probability is given by the classical Pollaczeck-Khinchine formula, which is an exponentially weighted sum of convolution integrals. The weights are exponentially decreasing with growing dimension. This fact gives rise to the suggestion, that quasi-Monte Carlo techniques could be efficient tools for numerical evaluation. For classical Monte Carlo algorithms, there exists a simple estimate for the error when the infinite-dimensional problem is approximated by a finite dimensional one using the variance of the function. In the case of quasi-Monte Carlo, knowledge about the variation is needed instead. However, it seems that the variation of the high-dimensional terms is growing super-exponentially and thus, it seems to be favourable to use a hybrid algorithm, i.e. to simulate only few terms in the Pollaczeck-Khinchine formula by quasi-Monte Carlo and the other terms by classical Monte Carlo.
Let F be a field and F[x,y] the ring of polynomials in two variables over F. Let f be a polynomial in F[x,y] and consider the residue class ring R = F[x,y]/f F[x,y]. In [1], digit representations in R are studied, i.e., we ask for which f each element in R admits a digit representation as a polynomial with coefficients in F[y] having degree less than f. These digit systems are motivated by the well-known notion of canonical number systems. In a next step, enlarge the space of representations in order to get representations with respect to negative powers of the base x. Dr. Scheicher characterized digit representations and gave easy-to-handle criteria for finiteness and periodicity. Finally, fundamental domains were attached to these number systems. The fundamental domain of a number system is the set of all numbers having only negative powers of x in their x-ary representation. Interestingly, the fundamental domains of these number systems set turn out to be unions of boxes. In case that F is a finite field, these unions become finite.
Let beta be a so called Pisot series, i.e. a formal Laurent series over F which is algebraic integer over F[x] with all algebraic conjugates having value less than one. The analogue of the beta expansions for the field of Laurent series was introduced together with Hbaib and Mkaouar. In [2], the set of Laurent series having purely periodic beta expansions is characterized. For this reason, several notions which are well known for number fields had to be introduced.
Dr. Scheicher left RICAM by the end of September 2007 and took up a research position at the Department of Mathematics at the University of Natural Resources and Applied Life Sciences in Vienna.

Scientific Cooperations

Internal
T. Beck (Symbolic Computation Group)

External
H. Brunotte (Düsseldorf)
J. Thuswaldner (MU. Leoben)
M. Jellali (Faculté des Sciences de Sfax)
M. Mkaouar (Faculté des Sciences de Sfax)

Publications

Appeared
[1] K. Scheicher, beta-expansions in algebraic function fields over finite fields. Finite Fields Appl., 13(2):394--410, 2007.
[2] K. Scheicher, Complexity and efficient simulation of discrete Levy areas. Journal of Complexity, 23(2):152--168, 2007.
[3] S. Akiyama and K.Scheicher, Symmetric shift radix systems and finite expansions. Mathematica Pannonica 18(1):101-124, 2007
[4] A. Huszti, K. Scheicher, P.Surer, and J. M.Thuswaldner, Three-dimensional shift radix systems, Acta Arithmetica 129(2), 147-166, 2007.

Submitted
[5] T. Beck, H. Brunotte, K. Scheicher, and J. M. Thuswaldner, Number systems and tilings over Laurent series

Work in progress
[6] M. Jellali, M. Mkaouar, and K. Scheicher, Purely periodic beta-expansions with pisot unit bases over Laurent series

Univ.-Doz. Dr. Arne Winterhof

Scientific Achievements 2007

Dr Winterhof is leader of an FWF project (Pseudorandom sequences (2006-2009), employees: Dr. Nina Brandstätter, Dr. Domingo Gomez, Dr. Gottlieb Pirsic). Since 2005 he is co-editor of the journal Finite Fields and Their Applications.

In 2007 Dr. Winterhof's and his coauthor's (Shparlinski (Sydney), Balasuriya (Sydney), Gutierrez (Santander), Meidl (Istanbul), Niederreiter (Singapore), Aly (Cairo), Brandstätter (Linz), Gomez (Linz), Pirsic (Linz), Sarközy (Budapest)) research has focused on the analysis of pseudorandom number generators for quasi-Monte Carlo applications [2,5,6], for cryptographic applications [1,3,8,10,11,13] and applications in algorithmic number theory [9]. He studied several quality measures (discrepancy, linear complexity and related measures) for binary sequences and nonlinear pseudorandom number generators. Besides the power generator, inversive generators and Dickson generators no other class of nonlinear pseudorandom generators with a linear complexity profile lower bound of exponential size (in the logarithm of the sequence length) had been known yet. In [4] another class of nonlinear generators with such a strong lower bound was found which is defined by recursions with Redei functions. A high linear complexity is not only necessary for the unpredictability and thus suitability of a sequence in cryptography but also for a fine lattice structure and thus suitability of the sequence for high-dimensional quasi-Monte Carlo methods. For cryptographic applications only a high linear complexity of a sequence is not enough. The linear complexity should not decrease essentially if it is allowed to change a few sequence elements. This leads to the concept of the k-error linear complexity. Exact values and strong lower bounds on the k-error linear complexity of some particular interesting binary sequences were proven in [3,8].
In [2] a general bound of Shparlinski and Niederreiter on exponential sums of nonlinear congruential pseudorandom number generators was improved which implies stronger results on the distribution of these sequences. In [5] much stronger bounds were obtained for the particularly interesting case of nonlinear generators with Redei function. In [6] a new idea combining the earlier concepts of explicit and recursive nonlinear pseudorandom number generators, the counter-dependent generator, was introduced and analyzed.

In [11,13] a new lattice test for nonlinear pseudorandom number generators was introduced which is much stronger than all its predecessors. The behaviour of several inversive generators was analyzed.
In [12] Prof Sarközy and Dr Winterhof defined some new quality measures for binary sequences constructed using finite fields and analyzed these measures for extensions of the Legendre sequence.
Moreover, Dr Winterhof continued his work on quantum period finding algorithms [4] in joint work with Prof. Shparlinski (Sydney) which has been started with Dr. Piroi (Symbolic Computation) in 2006. It was shown that a quantum algorithm of Hales and Hallgren can be used to determine the period of a sequence over a finite field if only a few most significant bits of some sequence elements are known. This result would imply the insecurity of several cryptographic systems if a quantum computer could be built. The case of binary sequences was analyzed earlier by Piroi and Winterhof.
Finally, Dr Winterhof and Prof. Shparlinski published a purely number-theoretic article on a certain distance defined for points on a modular hyperbola [7]. In particular, the number of different distances could be estimated using a combination of exponential sum estimates and techniques from the theory of uniform distribution. A related problem on the number of 'visible' points on multidimensional modular hyperbolas was attacked via character sum techniques in [13].
Dr Winterhof has supervised 3 bachelor theses (A. Altendorfer, C. Paul, M. Reischl). Dr Brandstätter finished her PhD in March under his supervision.

Scientific Cooperations

Internal
N. Brandstätter, D. Gomez, G. Pirsic: Cryptography and pseudorandom numbers

External
H. Aly (Cairo): Cryptographic sequences
S. Balasuriya (Sydney): pseudorandom numbers
J. Gutierrez Santander): pseudorandom numbers
W. Meidl (Istanbul): Cryptography, pseudorandom numbers
H. Niederreiter (Singapore): Pseudorandom numbers
P. Pop (Baia Mare): average distances in Waring graphs
A. Sarközy (Budapest): binary sequences
I. Shparlinski (Sydney): Cryptography, pseudorandom numbers, quantum algorithms

Lectures, Conferences, Scientific Visits and Talks

Lectures
Winter term 06/07: Coding theory (JKU Linz)
Summer term 07: Finite Fields (JKU Linz)
Winter term 07/8: Cryptography (JKU Linz)

Conferences
invited: Ecole d'Ete de Calcul Formel et Theorie des Nombres (Monastir, Tunesia): Pseudorandom numbers and number theory, August 27-31
contributed: Finite Fields Fq8 (Melbourne) Australia: On the k-error linear complexity over F_p of generalized Sidelnikov sequences, July 9-13
invited: University of Hildesheim: Number theory and pseudorandom sequences
contributed: AAECC 17 (Bangalore) India: On the structure of inversive pseudorandom number generators

Scientific Visits:
National University of Singapore , July 15-20.

Publications 2007

Appeared or accepted

[1] W. Meidl, A. Winterhof: On the linear complexity profile of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, 13(3):628-634, 2007
[2] H. Niederreiter, A. Winterhof: Exponential sums for nonlinear recurring sequences. Finite Fields and Their Applications, to appear, 2007
[3] H. Aly, W. Meidl, A. Winterhof: On the k-error linear complexity of cyclotomic sequences. Journal of Mathematical Cryptography, 1(3):283-296, 2007
[4] Shparlinski, A. Winterhof: Quantum period reconstruction of noisy sequences. Information Processing Letters, 103(6):211-215, 2007
[5] J. Gutierrez, A. Winterhof: Exponential sums of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, to appear, 2007
[6] S. Balasuriya, I. Shparlinski, A. Winterhof: An average bound for character sums with some counter-dependent recurrence sequences. Rocky Mountain Journal, to appear, 2007
[7] Shparlinski, A. Winterhof: On the number of distances between the coordinates of points on modular hyperbolas. Journal of Number Theory, to appear, 2007
[8] N. Brandstätter, A. Winterhof: k-error linear complexity of generalisations of Sidelnikov sequences. Workshop on Coding and Cryptography 2007, 29-38, 2007
[9] D. Gomez, A. Winterhof: Character sums of nonlinear recurrence sequences with Dickson polynomials, Proceedings Finite Fields and Applications Fq 8 (Melbourne, 2007), to appear.
[10] N. Brandstätter, A. Winterhof: Subsequences of Sidelnikov sequences, Proceedings Finite Fields and Applications Fq8 (Melbourne, 2007), to appear.
[11] H. Niederreiter, A. Winterhof: On the structure of inversive pseudorandom number generators, Applicable Algebra, Proceedings Applied Algebra, Algebraic Algorithms, and Error-Correcting Codes AAECC 17 (Bangalore, 2007), to appear

Submitted

[12] A. Sarközy, A. Winterhof: Measures of pseudorandomness for binary sequences constructed using finite fields
[13] I. Shparlinski, A. Winterhof: Visible points on modular hyperbolas
[14] G. Pirsic, A. Winterhof: On the structure of digital explicit nonlinear and inversive pseudorandom number generators

Dr. Nina Brandstätter

Scientific Achievements 2007

In 2007 Dr. Brandstätter's research focused on cryptographic functions and sequences.
She finished her PhD in March. In her thesis [1] she studied the relation between several quality measures for cryptographic functions and sequences and she also obtained several complexity lower bounds for some particular interesting sequences and functions.
In [2,3] she extended the classical concept of Sidelnikov sequences of period q-1 to arbitrary period and analyzed their k-error linear complexity over different fields. In [3] also the correlation measure was studied.
In [4] the concept of Sidelnikov sequences was generalized to sequences over non-prime fields.

Scientific Cooperations

Internal
Doz. Winterhof: Cryptographic functions and sequences

External
T. Lange (Kopenhagen): Boolean functions
W. Meidl (Istanbul): Cryptographic sequences

Conference Talks

International Workshop on Coding and Cryptography (WCC), INRIA-Rocquencourt, France, 16.04.2007 - 20.04.2007
Talk: k-error linear complexity of generalisations of Sidelnikov sequences

Publications 2007

Appeared
[1] N.Brandstätter: Pseudorandom number generators and character sums, PhD thesis, JKU Linz
[2] N.Brandstätter, A.Winterhof: k-error linear complexity of generalisations of Sidelnikov sequences, Workshop on Coding and Cryptography 2007, pages 29-38, 2007

To Appear
[3] N.Brandstätter, A.Winterhof: Subsequences of Sidelnikov sequences, Proceedings Finite Fields Applications Fq8 (Melbourne)

Submitted
[4] N.Brandstätter, W.Meidl: On the linear complexity of Sidelnikov sequences over non-prime fields

Dr. Domingo Gomez

Dr. Gomez is a former PhD student of J. Gutierrez (Santander) and joined RICAM in October 2006. He was supported by a grant of the Spanish Science Fund until December 2006 and was employed in Dr. Winterhof's FWF project from February to September 2007. He left RICAM for a permanent teaching position at his home university in Santander. His main research area is Applied Number Theory and Discrete Mathematics.

Scientific Achievements 2007

Dr. Gomez' research focused on theoretical analysis of pseudorandom numbers and algorithmic number theory.
In joint work with E. El-Mahassni (Sydney) [1,5] he studied the distribution of two nonlinear pseudorandom number generators over residue rings in terms of exponential sums. Such results had only been known for residue fields yet.
In [3] he proved with Dr. Winterhof character sum bounds of nonlinear recurrences with Dickson polynomials which are much better than the general case studied earlier by Dr. Winterhof and Prof. Niederreiter. Such bounds are helpful for a central problem of algorithmic number theory, finding primitive roots or elements of high order in a finite field.
With J. Gutierrez and A. Ibeas (Santander) he invented a root finding algorithm for multivariate polynomials over the integers [4].

Scientific Cooperations

Internal
Dr. Winterhof (Financial Mathematics)
J.M. Vallinas (Symbolic Computation)

External
J. Gutierrez (Santander)
A. Ibeas (Santander)
E. El-Mahassni (Sydney)

Conference Talks and Poster Presentations

LLL+25, Poster: "An algorithm for finding small roots of multivariate polynomials over the integers"

Finite Fields Conference Fq8, Melbourne (Australia), July 9-13:
Talk: "Multiplicative character sums for nonlinear recurring sequences with Dickson polynomials"

Publications 2007

Accepted

[1] E. El-Mahassni, D. Gomez On the distribution of counter-dependent nonlinear congruential pseudorandom number generators in residue rings, International Journal of Number Theory, to appear.
[2] D. Gomez, J. Gutierrez, A. Ibeas An algorithm for finding small roots of multivariate polynomials over the integers, Proc. LLL+25.
[3] D. Gomez, A. Winterhof: Multiplicative character sums for nonlinear recurring sequences with Dickson polynomials, Proceedings Finite Fields and Applications Fq 8 (Melbourne, 2007), to appear.

Submitted

[4] D. Gómez, J. Gutierrez and A. Ibeas: An algorithm for finding small roots of multivariate polynomials over the integers,University of Cantabria, Preprint 2006.
[5] E. El-Mahassni, D. Gomez: On the distribution of nonlinear congruential pseudorandom numbers of higher orders in residue rings, submitted to the Journal of Uniform Distribution.

Dr. Gottlieb Pirsic

Introduction

In this year the aim was to complete the existing projects in mathematical finance, possibly engage in further topics combining discrete or algebraic methods and financial mathematics and start to re-engage in number-theoretic and quasi-Monte Carlo related research. Starting from April 2007, Dr. Pirsic has been financed by the FWF P19004-N18 project led by Doz. Winterhof.

Scientific Activities 2007

In Actuarial Mathematics, Panjer-type recursions are known as an efficient way to compute discrete aggregate claim distributions, when the claim size and claim number distributions are of a certain type. In the (very general) case considered by Dr. Pirsic, the claim number probability generating function fulfils a linear differential equation with polynomial coefficients and the claim size probability generating function may be algebraic.
It was possible to reframe the results of Hesselager (with a less general claim number distribution) and then also those of Wang and Sobrero (full generality) in the context of the combinatorial/algebraic generating-function viewpoint. This was also achieved for the de Pril recursion, which is concerned with the moments of the aggregate claim distribution. A paper on this topic is in preparation.
A bound for the recursion length of the aggregate claims could be obtained for rational claim size distributions (and again holonomic claim number distributions) and was also investigated for the

general case of algebraic claim size distributions, the latter however turned out to be technically extremely involved).
Dr. Pirsic played an instrumental role in setting up the new collaboration with the Symbolic Computation Group on the symbolic treatment of boundary value problems related to insurance. Inside the Financial Mathematics group the collaborators are C. Constantinescu and H. Albrecher.
In cooperation with W. Schmid a numerical search for a specific kind of low-discrepancy sequence (permuted van der Corput sequences) was considered. The aim is in particular to find a base and permutation that beats a long existing best result of lowest discrepancy found "manually" by H. Faure and to implement his heuristics into a computer algorithm.
Another numerical project was to produce a statistic of the quality parameter t of the sub-class of (t,m,s)-nets known as cyclic digital nets and hyperplane nets.
With Doz. Winterhof there has been collaboration on the topics of sequences and exponential sums. Specifically, generalized lattice tests have been investigated for the class of digital explicit nonlinear pseudorandom number generators.

Scientific Cooperations

Internal
H. Albrecher (Financial Mathematics)
C. Constantinescu (Financial Mathematics)
A. Winterhof (Financial Mathematics)
G. Regensburger (Symbolic Computation)
M. Rosenkranz (Symbolic Computation)

External
W. Schmid (University of Salzburg): Low-discrepancy sequences, Computational number theory
H. Faure (University of Marseilles): Low-discrepancy sequences
M. Muthuswamy (University of Melbourne): Applications of algebraic function fields

Participation at Conferences, Scientific Visits and Talks

Conferences
- Workshop on Discrepancy Theory and Related Areas, Varenna, Italy, June 18–22,
- 6th International Congress on Industrial and Applied Mathematics (ICIAM), Zuerich, Switzerland, July 16-20
  Talk: "Numerical investigations of hyperplane nets"

Scientific Visit
University of Salzburg, W.Schmid (and H.Faure), November 21-22

Publications 2007

Appeared
[1] G. Pirsic, An inverse of the Faà di Bruno formula, INTEGERS: The Electronic Journal of Combinatorial Number Theory, A34, 7(2007).

Submitted
[2] G. Pirsic and A. Winterhof, On the Structure of Digital Explicit Nonlinear and Inversive Pseudorandom Number Generators, 2007.

4.6 GROUP "ANALYSIS OF PARTIAL DIFFERENTIAL EQUATIONS"

Group Leaders:
o.Univ.-Prof. Dr. Peter Markowich
Univ.-Prof. Dr. Christian Schmeiser

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Keith Anguige
Dr. Massimo Fonte
Dr. Massimo Fornasier
Dr. Arjan Kuijper

Introduction by Group Leader Prof. Christian Schmeiser

The group has had some fluctuation of PostDocs in the recent years, due to attractive job opportunities for some group members. The group is active mainly in three research fields:

Continuum models for large ensembles of biological cells: The activity has included the derivation of the classical Keller-Segel model and several extensions from kinetic transport equations, which are appropriate models of cells with 'run-and-tumble' behaviour. Recent highlights included RICAM internal cooperations on the asymptotic analysis of advection dominated chemotaxis models and on parameter identification for the Keller-Segel model. C. Schmeiser participated in a breakthrough concerning the two-dimensional Keller-Segel model, where the existence of global measure valued solutions for large initial-data has been proven. Finally, the macroscopic limit of models for cell-cell adhesion has been studied. Appropriate macroscopic models incorporating this effect are needed in many applications such as wound healing, tissue formation, angiogenesis, and other cell aggregation mechanisms. The study of this last subject is only in its early stages and will be continued in the coming years. RICAM PostDocs Yasmin Dolak-Struss and Keith Anguige have been mainly involved here.

Partial differential equations in image processing: The image processing activity includes work on PDE methods for mathematical inpainting as well as contributions to shape analysis. Two PostDocs and the group leader P. Markowich are involved in the project "Mathematical Methods for Image Analysis and Processing in Visual Arts" funded by the Viennese research fund WWTF (4 years, 400 kEuro). This will be the main activity for the coming years involving also a number of external cooperations. New actitivities will include internal cooperations with the RICAM imaging group as well as with C. Schmeiser WWTF project on cytoskeletal dynamics, where new types of image analysis problems occur in the treatment of electron microscope pictures of the actin cytoskeleton. RICAM PostDocs Shun-Yin Chu, Massimo Fornasier and Arjan Kuijper have been mainly involved here.

Conservation laws and kinetic transport equations: Recent work on kinetic transport models involved the rigorous derivation of macroscopic limits, as well as the dynamic stability of equilibria and travelling waves. Another topic is the analysis of dispersive conservation laws such as the Camassa-Holm equation and the Kadomtsev-Petviashvili equation. For the former, new existence results for weak solutions have been derived, and for the latter, uniform estimates for oscillatory regimes have been shown. Work on the Kadomtsev-Petviashvili equation is also motivated by its use in the mathematical description of the dynamics of Bose-Einstein condensates, which creates a connection to a major research activity of both group leaders. RICAM PostDocs Lukas Neumann and Massimo Fonte have been mainly involved here.

In the following, the PostDocs describe their individual work.

Dr. Keith Anguige

Scientific Achievements 2007

In 2007, there has been a continuing collaboration with Prof. Christian Schmeiser on a class of adhesion-diffusion problems in the general area of cell-motility modelling.
The basic aim here has been to develop and analyse continuum models for the motion of a system of particles which can to some extent move randomly, but whose movements are restricted by volume filling and cell-to-cell adhesion - the motivation for the modelling is to gain an understanding of structure formation in biological processes such as gastrulation and vasculogenesis in the early embryo.
Previously, in 2006, a discrete 1-d random-walk model for this situation had been written down and subjected to numerical and mathematical investigation, and a brief summary of the results obtained now follows.
For small values of the adhesion coefficient, the continuum limit of the model (a nonlinear diffusion equation for the cell density) has a positive (density-dependent) diffusivity, D, and numerical solutions of the discrete model closely mimic the behaviour of this equation; in particular, all initial inhomogeneities in the density distribution smooth out over time, leaving a uniform profile at steady state.
On the other hand, for large values of the adhesion coefficient, and sufficiently large initial data, a number of rather more interesting phenomena, such as plateau formation, fine spatial oscillations, and coarsening behaviour become possible. These phenomena are related to the ill posedness of the limiting equation in this case, for which there is an interval of values of the density such that $D<0$, and they can be understood via a combination of linear stability analysis of the discrete model and steady-state analysis of the limiting continuum equation (and higher-order corrections thereof).
An outstanding mathematical problem arising from this early work was to show rigorously that the discrete model (which can be thought of as a "method-of-lines" approximation) converges to the formal continuum limit in the low-adhesion regime, and this result was in fact obtained earlier this year.
The ill posedness of the formal limiting equation in the high-adhesion regime raises the question as to just what one should take to be the continuum limit in this case. One possibility is to allow solutions which jump across the "forbidden" region where $D<0$, and which satisfy the formal limiting equation elsewhere; the mathematical challenge here is to solve a kind of multi-phase Stefan problem for the cell density. In the (simplest) case of a single jump discontinuity, uniqueness of solutions and *a priori* estimates on the long-time convergence to (plateau) steady state have been proven; the desired global-existence theorem is a plausible outcome of ongoing analytical work.
One obvious way of extending the basic 1-d adhesion model is to factor in chemotactic effects, thereby enabling one to investigate the interaction of short-range (adhesion) and long-range (chemotaxis) signalling. In line with this, an appropriate discrete model, along with its continuum limit, have now been written down and subjected to mathematical and (preliminary) numerical analysis.
In the low-adhesion regime, model behaviour is akin to that of the Keller-Segel model with volume filling, such that (smooth) aggregation is possible for high chemotactic sensitivities.
In the high-adhesion regime, the continuum limit is again ill-posed, and, with high chemotactic sensitivity, numerical simulations of the underlying discrete model show that one can obtain sharp-edged aggregation regions from an initial datum which is a small perturbation of a low, uniform initial density – behaviour which is not seen in the basic adhesion model.
Of course, it is also desirable to extend the adhesion model to two dimensions, and an appropriate discrete model has now been written down. Once more, the continuum limit is a nonlinear diffusion equation with a diffusivity which can turn negative if there is sufficient adhesion. Construction of plateau steady-state solutions, along with linear stability analysis near uniform solutions, leads one to expect solution behaviour which is qualitatively similar to that observed in the 1-d case.

Scientific Cooperations

Internal
Prof. Christian Schmeiser

Participation at Conferences, Scientific Visits, and Talks

Conferences
- Slovak-Austrian Mathematical Congress, Podbanske (Slovakia), 16th-21st September, 2007.
- Workshop on Biomechanics and Chemotaxis, as part of the Special Semester on Quantitative Biology Analysed by Mathematical Methods, RICAM Linz (Austria), 10th-14th December, 2007.

Scientific Talks
- "A one-dimensional model of cell diffusion and aggregation, incorporating volume filling and cell-to-cell adhesion", 20th September 2007, Podbanske (Slovakia).
- "A one-dimensional model of cell diffusion and aggregation, incorporating volume filling and cell-to-cell adhesion", 11th December 2007, RICAM Linz (Austria).

Publications 2007

Submitted

[1] K. Anguige, C. Schmeiser: A one-dimensional model of cell diffusion and aggregation, incorporating volume filling and cell-to-cell adhesion, submitted.

Dr. Massimo Fonte

Scientific Achievements Year 2007

Dr. Fonte's research area concerns non-linear partial differential equations of hyperbolic type. He studies some non-linear models arising from mathematical physics and, in particular, the issue of blow-up for a non-linear shallow water wave equation in 1-d. He mainly devoted his research to the construction of solutions which are stable with respect to a Wasserstein-like metric. He is also interested in conservation laws in 1-D and multi-D.
Dr. Fonte's research work in the first part of 2007 was mainly dedicated to the study of the Camassa-Holm equation, which is an analytical model of water waves in the shallow water regime. This non-linear P.D.E. has a Hamiltonian structure, and it was widely studied by several authors in the nineties, but a general result of existence and continuous dependence with respect to the initial data could not be found. In collaboration with Prof. A. Bressan, a first result was proved for spatially-periodic initial data by introducing a distance, defined in term of optimal transportation. Recently, Dr. Fonte has extended this result to a wider class of initial data. A key role is played by the solitary waves of the system, because of their persistence in time. Starting from the P.D.E., a Hamiltonian system of O.D.E. for the coefficients of the solitary waves was constructed. This system was well studied in the literature whenever blow-up does not occur, but classical solutions cannot be extended in the presence of wave breaking. The solutions are thus obtained by performing a change of variable, in order to resolve all the singularities which appear in a finite time. All these results can be applied only for solutions which conserve the energy of the model.
In the first part of 2007, Dr. Fonte focused his work on the study of the so-called "dissipative solutions" of the Camassa-Holm equation. In this case, this equation has a physical meaning as the "hyperelastic-rod wave equation". He performed the construction of a semigroup of dissipative

solutions, via resolution of a discontinuous system of O.D.E., and the definition of a metric space (X, d) for which continuous dependence fits well.
In collaboration with Prof. Peter Markowich, Dr. Fonte starts the study of the so-called Kadomtsev-Petviashvili equation. This equation arises as a model for strong and weak surface tension, moreover it describes the two-dimensional model nonlinear matter-wave pulse in Bose-Einstein condensates. Until now, numerical results on oscillatory regimes are well known, but analytical results fail to be achieved. By using a "splitting operator" approach, a first stability result in a dispersionless regime is proved.
Dr. Fonte was appointed as the Scientific Adviser for two "RICAM-ICIAM" grant winners in the period of July 2007.

Scientific Cooperations

Internal
Prof. Dr. Peter Markowich

External
Dr. Fabio S. Priuli, NTNU Trondheim (Norway)

Participation at Conferences, Scientific Visits and Talks

Conferences
- INDAM, International Workshop on Nonlinear Hyperbolic Problems. Università di Roma "La Sapienza", Rome (Italy), May 28th - June 1st 2007.
- Fifth meeting on Hyperbolic Conservation Laws: Recent results and Research perspectives. International School of Advanced Studies, Trieste (Italy), June 21st – 22nd 2007.
- Sixth ISAAC Congress, Middle East Technical University, Ankara (Turkey), August 13th – 18th 2007.

Scientific Talks
- Conservative and Dissipative solutions of the Camassa-Holm equation. June 22nd 2007, Trieste (Italy).
- Case study of solutions for the Camassa-Holm equation. Special Session on "Dispersive Equations", August 15th 2007, Ankara (Turkey).

Publications 2007

Submitted
[1] M. Fonte, On the dissipative solutions for the Camassa-Holm Equation on the real line, Submitted.

Dr. Massimo Fornasier

Scientific Achievements 2007

Two major external projects of Dr. Fornasier were approved in Oct.-Nov. 2006: 2006 WWTF "Five Senses - Call 2006" (4 years, 400 kEuro), "Mathematical Methods for Image Analysis and Processing in Visual Arts" (joint project with Prof. Dr. P. Markowich), and the Outgoing International Marie Curie Fellowship (18 months, 120 kEuro) "Sparse Approximation for Blind-Source Separation" (individual project). The first project is concerned with variational and PDE methods for image analysis in the visual arts, and in particular for the *mathematical inpainting* of the Neidhart frescoes in Vienna (1. ,Tuchlauben 19). Novel image recolorization and inpainting models were investigated, based on the solution of variational problems involving total variation minimization, via systems of coupled

nonlinear PDE's. Both mathematical and numerical analysis were provided [A9-10]. The second project is focussed on the solution of inverse problems with sparsity constraints (see [A7-8,S3-5]), and applications in brain imaging (fMRI and magnetoencephalography). Dr. Fornasier joined RICAM on June 1, 2006 and, with an unpaid leave of 1 year, started a cooperation within the Program in Applied and Computational Mathematics (PACM), Princeton University, USA, on the basis of this second individual project. During 2007, Dr. Fornasier was indeed mostly committed to developing this project at PACM, in cooperation with Prof. Ingrid Daubechies. In particular, he focussed on the formulation and the analysis of iterative methods for the solution of inverse problems with sparsity constraints with respect to frame decompositions. These iterative schemes are typically subgradient algorithms (e.g., thresholded Landweber iterations) [A8,S4], implicitly solving systems of nonlinear subdifferential inclusions, and often exhibit a very slow convergence rate. Accelerations due to projected gradient steps [S5] and domain decomposition/subspace correction methods [S3] were investigated, as well as their fine-convergence properties. Applications in brain imaging, geophysics and color-image recovery were also specifically addressed [A7-8]. During his stay in Princeton, Dr. Fornasier applied for an ERC "Starting Independent Researcher Grant" with the project "Calculus of Variations for Sparse Recovery and Learning Theory" (VarSpaLt). Two Master students successfully concluded their studies at the University of Padua, Italy, under the supervision of Dr. Fornasier, respectively Giulia Erica Valente (Thesis title: "Gabor frames: teoria e algoritmi", Department of Pure and Applied Mathematics) and Rocco Cazzato (Thesis title: "Metodi di ricolorazione di immagini ed applicazioni al restauro", Department of Information Engineering).

Scientific Cooperations

Internal
Prof. Dr. Peter Markowich
Dr. Arjan Kuijper
PD. Dr. Ronny Ramlau (Inverse Problems)

External
Dr. Maria Charina, Institute for Applied Mathematics, University of Dortmund Germany
Prof. Costanza Conti, Energetic Department "Sergio Stecco", University of Florence Italy
Prof. Stephan Dahlke, AG Numerik/Wavelet-Analysis Group, Philipps-University of Marburg Germany
Prof. Ingrid Daubechies, Program in Applied and Computational Mathematics, Princeton University U.S.A.
Prof. Ronald A. DeVore, Department of Mathematics, University of South Carolina U.S.A.
Prof. Hans G. Feichtinger, Numerical Harmonic Analysis Group, University of Vienna Austria
Prof. Karlheinz Gröchenig, Numerical Harmonic Analysis Group, University of Vienna Austria
Prof. Laura Gori, Department of Math. Methods and Models for Appl. Sci., University of Rome "La Sapienza Italy"
Dr. Sinan Güntürk, Department of Mathematics, Courant Institute of Mathematical Sciences, New York University U.S.A.
Dr. Ignace Loris, Dienst Theoretische Natuurkunde, Vrije Universiteit Brussel Belgium
Dr. Riccardo March, IAC "Mauro Picone" Rome, National Council of Research Italy
Prof. Francesca Pitolli, Department of Math. Methods and Models for Appl. Sci., University of Rome "La Sapienza" Italy
Dr. Holger Rauhut, Numerical Harmonic Analysis Group, University of Vienna Austria
Mag. Carola B. Schönlieb, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK
Prof. Gabriele Steidl, Faculty of Mathematics and Computer Sciences, University of Mannheim Germany
Prof. Rob Stevenson, Department of Mathematics, University of Amsterdam Holland
Dr. Gerd Teschke, Konrad-Zuse-Zentrum fuer Technomathematik Berlin Germany

Prof. Domenico Toniolo, Department of Physics "G. Galilei", University of Padua Italy
Dr. Joel Tropp, Engineering & Applied Science, California Institute of Technology, U.S.A.

Participation at Conferences, Scientific Visits and Talk

Conferences

[C1] Invited talk, Scale Space Variational Methods 2007, Ischia, Italy, May 30 - June 2, 2007.
[C2] Invited talk, Mini-workshop on "PDE's and Variational Tools in Image Inpainting", Wolfgang Pauli Institute, Vienna, Austria, June 11-13, 2007.
[C3] Invited talk, International Conference "Trends in Harmonic Analysis", Strobl, Austria, June 18-22, 2007.
[C4] Invited talk, Conference on Applied Inverse Problems 2007: Theoretical and Computational Aspects, June 25-29, 2007.
[C5] Invited talk 2007 von Neumann Symposium "Sparse Representation and High-Dimensional Geometry", July 8-12, 2007.
[C6] Plenary lecture at "SCCH 2007: Scientific Computing and the Cultural Heritage IWR Workshop", November 12-14, 2007, Heidelberger Akademie der Wissenschaften, Germany.

Scientific Visits

- Program in Applied and Computational Mathematics, Princeton University, USA, Oct. 2006-Oct. 2007.
- Courant Institute of Mathematical Sciences, New York University, USA, Feb.-May 2007.
- Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK, 21-30 November 2007.

Scientific Talks

[T1] *A unified approach to iterative thresholding algorithms for sparse recovery,* Norbert Wiener Center Seminar, University of Maryland, USA, April 12, 2007.
[T2] *Iterative Thresholding Algorithms for Inverse Problems with Sparsity Constraints,* Harmonic Analysis and Signal Processing Seminar, Courant Institute of Mathematical Sciences, NY University, USA, April 30, 2007.
[T3] *Recent advances in numerical harmonic analysis,* Mini-course for undergraduate students, Department of Pure and Applied Mathematics, University of Padua, Italy, June 5-8, 2007.
[T4] Tutorial course at the Dolomites Research Week on Approximation 2007, Alba di Canazei, Trento (Italy), September 3-7, 2007.
[T5] Invited lecture „Mathematics and art restoration", Institut für Konservierung und Restaurierung, Akademie der bildenden Künste Wien, November 9 2007.
[T6] Presentation of the project "Mathematical Methods for Image Analysis and Processing in the Visual Arts", WWTF, December 5 2007.
[T7] Invited talk, Informationsveranstaltung "PEOPLE & IDEAS - Projekte im 7. EU-Rahmenprogramm", ÖAW, December 7, 2007.

Publications 2007

Appeared [A]

1. M. Fornasier: *Banach frames for alpha-modulation spaces,* Applied and Computational Harmonic Analysis, Volume 22, Issue 2, March 2007, Pages 157-175.
2. S. Dahlke, M. Fornasier, T. Raasch: *Adaptive frame methods for elliptic operator equations,* Advances in Computational Mathematics, Volume 27, Number 1, 2007, Pages 27-63.

3. M. Fornasier: *On some stability results of localized atomic decompositions***,** Rendiconti di Matematica e delle sue Applicazioni, Volume 26, Number 3-4, 2006, Pages 315-325.
4. S. Dahlke, M. Fornasier, T. Raasch, R. Stevenson, M. Werner: *Adaptive frame methods for elliptic operator equations: the steepest descent approach***,** IMA Journal of Numerical Analysis, Volume 27 Number 4, 2007, Pages 717-740.
5. S. Dahlke, M. Fornasier, H. Rauhut, G. Steid, G. Teschke: *Generalized coorbit theory, Banach frames, and the relation to alpha-modulation spaces,* to appear in Proceedings of the London Mathematical Society, 2007.
6. M. Fornasier, L. Gori: *Sampling theorems on bounded domains,* to appear in J. Comput. Appl. Math., 2007.
7. M. Fornasier, F. Pitolli: *Adaptive iterative thresholding algorithms for magnetoencephalography,* to appear in J. Comput. Appl. Math., 2007.
8. M. Fornasier, H. Rauhut*: Recovery algorithms for vector valued data with joint sparsity constraints*, to appear in SIAM J. Numer. Anal., 2007.
9. M. Fornasier, R. March: *Restoration of color images by vector valued BV functions and variational calculus*, SIAM J. Appl. Math. Volume 68 Nnumebr 2, 2007, Pages 437-460.
10. M. Fornasier: *Faithful recovery of vector valued functions from incomplete data. Recolorization and art restoration,* Lecture Notes in Computer Science, Volume 4485/2007, Proceedings of the First International Conference on Scale Space Methods and Variational Methods in Computer Vision (Sgallari, Fiorella; Murli, Almerico; Paragios, Nikos Eds.), 2007, Pages 116-127.
11. C. Charina, C. Conti, M. Fornasier: *Adaptive frame methods for nonlinear variational problems,* to appear in Numer. Math., 2007.
12. M. Fornasier: *Domain decomposition methods for linear inverse problems with sparsity constraints,* Inverse Problems, Volume 23**,** 2007, Pages 2505–2526.
13. M. Fornasier and H. Rauhut: *Iterative thresholding algorithms,* to in appear Appl. Comput. Harm. Anal., 2007.
14. I. Daubechies, M. Fornasier and I.Loris: *Accelerated projected gradient method for linear inverse problems with sparsity constraints*, to appear in J. Four. Anal. Appl., 2007.

Submitted [S]
1. M. Fornasier, S. Dahlke, K. Gröchenig: *Optimal adaptive computation in the Jaffard algebra and localized frames,* RICAM report no. 2006-28, Aug. 2006, submitted to Numer. Math., 2006
2. M. Fornasier, G. Teschke and R. Ramlau*: A comparison of joint sparsity and total variation minimization algorithms in a real-life art restoration,* submitted to Adv. Comput. Math.**,** November 2007, 23 pp.
3. S. Dahlke, M. Fornasier M. Primbs, T. Raasch, and M. Werner*: Nonlinear and adaptive frame approximation schemes for elliptic PDEs: theory and numerical*, submitted to Numerical Methods for Partial Differential Equations, November 2007, 43 pp.

Dr. Arjan Kuijper

Scientific Achievements
Arjan Kuijper primarily studied the structure of images changing under the influence of two classes of non-linear partial differential equations (PDEs). The first class consists of the p-Laplacians [2, 4, 6, 9, 10], while the second one contains weighted combinations of second-order derivatives in gauge coordinates [2, 4, 7, 10]. Special attention is paid to efficient numerical implementations [6, 7]. These classes have Gaussian scale space in common; their relations are described [2, 4]. In this framework, an analysis of the topological multi-scale structure and a method to derive it efficiently has been derived. Effective extensions of this framework to the non-linear PDEs are currently under research.

Secondly, he continued his work on shape analysis using the Symmetry Set [3, 5], including relations to the Medial Axis [3] and its multi-scale structure [5], in collaboration with people from the University of Copenhagen, Denmark and the University of Liverpool, UK. Application of and matching algorithms using a variant of the Symmetry Set applied to human genome shapes has been carried out in collaboration with Dr. Havukkala, New Zealand [5].
A third line of research is inspired by applications in the bio-sciences [1, 11], and consists of applying geometric PDEs in a level set framework to confocal microscopy images. This work initiated during the supervision of his MSc. student Y. Zhou [8]. Results on automatic segmentation using a voting scheme were obtained in collaboration with B. Heise, Johannes Kepler University in Linz [14], while segmentation using a more sophisticated level-set scheme in combination with a Perona-Malik type of pre-processing was obtained in collaboration with Dr. He of the inverse problems group.
His research has been and will be presented at various conferences, workshops, and scientific meetings.

He has been participant in the WWTF Proposal (Five senses-Call 2006), "Mathematical Methods for Image Analysis and Processing in the Visual Arts" (funding volume: 400,000 € / project duration: 4 years).
He taught a course on "Image Analysis and Processing" at Kepler University Linz in the winter semester 2006-2007, attended by people of various RICAM groups (Inverse Problems, Analysis of PDEs, and Mathematical Imaging) and the Department of Knowledge-Based Mathematical Systems - Fuzzy Logic Laboratorium Linz-Hagenberg. He also taught a course on Level Set Methods in the summer semester 2007.
He supervised the MSc. Thesis project "Cell Segmentation using the Level Set Method" (summer semester 2007) [8]. He took examinations at two MSc. Defences (July 2007).

He was a referee for international peer reviewed journals & conferences:
- IEEE Transactions on Image Processing,
- International Journal of Computer Vision,
- Journal of Mathematical Imaging and Vision,
- Electronic Letters in Computer Vision and Image Analysis,
- 14th International Conference on Image Processing (ICIP07),
- 1st joint Scale-Space and Variational Methods Conference (SSVM 07),.
- 31st annual workshop of the Austrian Association for Pattern Recognition, OEAGM07,
- Mathematical Methods in Biomedical Image Analysis (MMBIA07).

He was a member of the Programme Committees of
- The First joint Scale-Space and Variational Methods Conference (SSVM 07), May 30 - June 2, 2007, Ischia, Italy, and
- The 31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07, May 3-4, 2007 Schloss Krumbach, Austria.
- MMBIA07 (Mathematical Methods in Biomedical Image Analysis, 14-15 October, 2007, Rio de Janeiro, Brasil).

He was an organiser of
- the workshop "Image Analysis in the Life Sciences Theory and Applications", Linz, February 26 - 28, 2007 (14 invited speakers). Together with Leila Muresan and Dr. Peter Bauer, Department of Knowledge-Based Mathematical Systems - Fuzzy Logic Laboratory Linz-Hagenberg, Austria,
- the workshop "BioImaging II/PDE methods" (20 invited speakers), November 19 - 23, 2007. It is part of the "Special Semester on Quantitative Biology analysed by Mathematical Methods", to be held at RICAM, October 1, 2007 - January 27, 2008. Together with Prof. Markowich and Prof. Scherzer, RICAM, and

- the 8-speaker mini-symposium "The role of scale and orientation in mathematical image analysis" at the 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007, Zürich, Switzerland.

Arjan Kuijper is a member of SIAM, SIAM-IS, IEEE, IEEE-SPS, AAPR, and IAPR.

Scientific Cooperations

Internal
Prof. Dr. Peter Markowich, RICAM/ Univ. of Vienna, Austria/ Univ. of Cambridge, U.K.
Dr. Peter Elbau, RICAM
Dr. Bastian Gebauer, RICAM
Dr. Lin He, RICAM
Dr. Massimo Fornasier, RICAM / Princeton

External
Leila Muresan, Bettina Heise, Dr. Peter Bauer, Department of Knowledge-Based Mathematical Systems - Fuzzy Logic Laboratory Linz-Hagenberg, Austria.
Dr. Norayr Matevosyan, Carola Schoenlieb, Dept. of Mathematics, University of Vienna, Austria & University of Cambridge, U.K.
Adrian Ion, Vienna University of Technology, Vienna, Austria.
Dr. Ole Fogh Olsen, Prof. Dr. Mads Nielsen, Dr. Marco Loog, Image group, University of Copenhagen, Denmark.
Prof. Dr. Peter Giblin, Dept. of Mathematics, University of Liverpool, United Kingdom.
Prof. Dr. Bart Ter Haar Romeny, Dept. of Biomedical Image Analysis, Technical University of Eindhoven, the Netherlands.
Prof Dr. Luc Florack, Depts. of Mathematics and Biomedical Image Analysis, Technical University of Eindhoven, the Netherlands.
Dr. Khoa N. Le, Griffith University, Australia.
Dr. Ilkka Havukkala, Knowledge Engineering and Discovery Research Institute, Auckland University of Technology, New Zealand

Participation at Conferences, Scientific Visits, and Talks

Conferences
- The First joint Scale-Space and Variational Methods Conference, May 30 - June 2, 2007, Ischia, Italy.
- PDE and Variational Tools in Image Inpainting at the Wolfgang Pauli Institute (11-13 June 2007, Vienna).
- 31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07 (Schloss Krumbach, Austria, May 3-4, 2007).
- 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007).
- 9th IASTED International Conference on Signal and Image Processing (SIP 2007, Honolulu, Hawaii, USA, August 20-22, 2007).
- 14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007).

Scientific Visits
- Wolfgang Pauli Institute, Vienna, Austria, June, September 2007.
- University of Applied Arts, Vienna, Austria, July 2007.
- Vienna University of Technology, Vienna, Austria, July 2007.

- James Clarke Maxwell Telescope, Hilo, Hawaii, U.S.A., August 2007.
- Software Competence Centre Hagenberg (SCCH), Fuzzy Logic Laboratory Linz Hagenberg (FLLL), & Fachhochschule Hagenberg, Hagenberg, Austria, regularly 2007.

Scientific Presentations

- "Inpainting with higher order energies", in the workshop "PDEs and Variational Tools in Image Inpainting", Wolfgang Pauli Institute (WPI), Vienna, Austria, June 2007.
- "Image analysis using p-Laplacian and geometrical PDEs", Wolfgang Pauli Institute (WPI), Vienna, Austria, June 2007.
- "Image analysis using p-Laplacian and geometrical PDEs," in the 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007, Zurich, Switzerland, July 2007.
- "Computationally efficient matching of microRNA shapes using mutual symmetry," in the 9th IASTED International Conference on Signal and Image Processing, SIP 2007, Honolulu, Hawaii, USA, August, 2007.
- "Image processing with geometrical and variational PDEs," in the 31st annual workshop of the Austrian Association for Pattern Recognition, OEAGM07, Schloss Krumbach, Austria, May 2007,
- "p-Laplacian driven image processing," in 14th the International Conference on Image Processing, ICIP 2007, San Antonio, Texas, USA, September 2007.
- "Images at Multiple Scales", WWTF meeting, Wolfgang Pauli Institute (WPI), Vienna, Austria, September 2007.

Publications

Appeared

[1] F. Bauer, A. Kuijper, and L. Muresan, eds., International Workshop on Image Analysis in the Life Sciences; Theory and Applications, 2007.

[2] A. Kuijper, "Image processing with geometrical and variational PDEs," in 31st annual workshop of the Austrian Association for Pattern Recognition, OEAGM07, (Schloss Krumbach, Austria, May 3-4, 2007), pp. 89–96, 2007.

[3] A. Kuijper, "Deriving the medial axis with geometrical arguments for planar shapes," *Pattern Recognition Letters*, vol. 28, no. 15, pp. 2011–2018, 2007.

[4] A. Kuijper, "Image analysis using p-Laplacian and geometrical PDEs," in 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007), p. 157, 2007.

[5] A. Kuijper and I. Havukkala, "Computationally efficient matching of microRNA shapes using mutual symmetry," in *9th IASTED International Conference on Signal and Image Processing, SIP 2007 (August 20 22, 2007 Honolulu, Hawaii, USA)*, pp. 477–482, 2007.

[6] A. Kuijper, "p-Laplacian driven image processing," in 14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007), Vol. V, pp. 257–260, 2007.

[7] A. Kuijper, "Qualitative and Quantitative Behaviour of Geometrical PDEs in Image Processing", in 8th Asian Conference on Computer Vision, ACCV 2007 (Tokyo, Japan, Nov. 18-22, 2007), LNCS 4843, pages 230--239, 2007.

[8] Y. Zhou, A. Kuijper, B. Heise, L. He , "Cell Segmentation Using the Level Set Method", Technical Report RICAM no. 2007-17 , 2007.

[9] A. Kuijper, "p-Laplacian driven image processing", Wittgenstein Research Group Preprints Vienna, no. 104, 2007.

[10] A. Kuijper, "Image Processing with Geometrical and Variational PDEs", Wittgenstein Research Group Preprints Vienna no. 103, 2007.

[11] A. Kuijper, O. Scherzer, and P. Markowich, eds., "BioImaging II/PDE methods", 2007.

[12] A. Kuijper**, "**Book review: Geometric Tomography, J. Gardner", IAPR newsletter, 25 (5), 5--6, October 2007

Accepted

[13] Y. Zhou, A. Kuijper, and L. He, "Multiphase Level Set Method and its Application in Cell Segmentation", 5th IASTED International Conference on Signal Processing, Pattern Recognition, and Applications (SPPRA 2008, Innsbruck, Austria, February 13 – 15, 2008), pages ..-.., 2008.

[14] A. Kuijper, Y. Zhou, and B. Heise, "Clustered Cell Segmentation - Based on Iterative Voting and the Level Set Method", 3rd International Conference on Computer Vision Theory and Applications (VISAPP, Funchal, Portugal, 22 - 25 January 2008), pages ..-.., 2008.

Dr. Shun-Yin Chu

Scientific Achievements 2007(up to 30th April)

He started exploring some well-known results and basic techniques of general perturbation theory of some first order ordinary differential systems involving variation of one and two parameters. The study of patterns of phase portrait and construction of center manifold on resonant systems may help to find patterns of behaviour of perturbations on stable solutions of Cahn-Hilliard equation.

Another topic which he is interested is the stability of boundary layer on fluid mechanics. From the study of Blasius equation, the laminar flow analysis on boundary layer of two-dimensional viscous flow problem on Dirichlet boundary condition, Neumann boundary condition and mixed type boundary condition are studied. Some boundary layer problems of rotating flows on the circular boundary will be concerned.

Some topics such as regularity, blowup, well-posedness and asymptotic problems of Camassa-Holm equation with Y.Zhou will be continued. In particular, they worked on the characterization of the blowup solution by initial data.

Scientific Cooperations

Internal

Prof. Dr. Peter Markowich

Prof. Dr. Christian Schmeiser

External

Dr. Yong Zhou, East China Normal University, China

Publications 2007(up to 30th April)

Submitted

[1] S.Y. Chu, Global Existence of Weak Solutions to 3-D Axisymmetric Prandtl's System with both Stagnation Point Flow and Positive Swirls

[2] M. Burger, S.Y. Chu, P. Markowich and C.B. Schönlieb, The Willmore Functional and Instabilities in the Cahn-Hilliard Equation

Scientific plans for 2007(after 1st May)

The partial research works will be continued. A series of fluid mechanics and boundary layer problems such as stability and regularity are started. He and Zhou will explore the blowup type solutions of Camassa-Holm equation with the help of spike solutions and conserved quantities. Asymptotic behaviour of anisotropic flows and evolution of bubbles of Cahn-Hilliard equation is followed in a crossover project.

4.7 GROUP "OPTIMIZATION AND OPITIMAL CONTROL"

Group Leaders:
o.Univ.-Prof. DI. Dr. Karl Kunisch

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Roland Griesse
Dr. Xiliang Lu
Dr. Boris Vexler

Researchers externally funded:
Dipl. Math. Techn. Olaf Benedix
Mag. Nataliya Metla
Dipl. Math. Martin Bernauer

Introduction by Group Leader Prof. Karl Kunisch

The focus of the group is on infinite dimensional optimization problems with partial differential equations as constraints. The group has acquired three FWF – Projects. It is involved in numerous external cooperations, involving joint publications, and in the following cooperations within the Radon institute:

1) Computational Mathematics for Direct Field Problems: Control of magneto-hydro-dynamics
2) Inverse Problems: Optimal Control with Singularities
3) Financial Mathematics: Portfolio Optimization

The research activities during 2007 continued to address stability and sensitivity concepts in continuous optimization. Sufficient second-order optimality conditions and a convergence analysis for SQP methods for mixed constrained optimal control problems were investigated.

Active set methods and semi-smooth Newton methods for portfolio optimization problems with proportional transaction costs were investigated in the framework of nonsmooth complementarity systems.

Algorithms for adaptive discretization techniques are very important for efficient solution of optimization problems governed by partial differential equations. The resulting algorithms are based on a posteriori error estimators, which provide quantitative information on the discretization error and allow for substational saving in degrees of freedom.

Significant progress insight was also obtained on the issue of "optimize-then-discretize" and "discretize-then-optimize". For time discretization based on discontinuous Galerkin techniques these two approaches typically commute.

Future Research

Future research will continue to be primarily in the area of PDE constraint optimization.

<u>Optimal Control of Stefan Problems with Constraints</u>
One of the future topics is the optimal control of free (moving) boundary problems involving time-

dependent PDEs. Free boundary problems are ubiquitous, e.g., in physical phenomena involving phase transitions, of which the Stefan problem is a prototype. Our research will concentrate in particular on the analysis and numerical methods for Stefan problems with constraints on the location of the free boundary, for instance, in order to prevent the moving boundary from entering a specified area. An FWF project in this area, led jointly by Dr. Griesse and Prof. Kunisch, has been approved for funding in June 2007. DI Martin Bernauer has started working in this project in August 2007. Within this project, we pursue mainly three goals:

- to establish and analyze necessary conditions of optimality
- to devise fast function-space oriented optimization techniques for their solution
- to implement numerical methods to verify the practical behavior of the proposed algorithms.

Algorithms for Optimal Control Problems with Mixed Control-State Constraints

Optimal control problems with mixed control-state constraints are relevant as a regularization technique for problems with pure state constraints, but they are also interesting in their own right. The development of fast numerical schemes is essential for the efficient solution of these problems. In an ongoing FWF project led by Dr. Griesse and Prof. Rösch, Dipl.-Math. Metla proved the fast local convergence of the SQP method for semilinear elliptic problems with linear constraints. In the future, we will focus on problems with nonlinear constraints, boundary control problems, as well as parabolic equations.

Numerical analysis and discretization strategies for optimal control problems with singularities (B. Vexler with A. Rösch, Th. Apel and O. Benedix).

Within the joint FWF-DFG project "Numerical analysis and discretization strategies for optimal control problems with singularities" the first goal is to develop an adaptive mesh refinement algorithm for solution of optimal control problems with pointwise inequality state constraints. The main challenge is the treatment of singularities introduced by active state constraints with a priori unknown location.

Adaptive finite elements for efficient computation of the regularization parameter in inverse problems (B. Vexler with B. Kaltenbacher and A. Griesbaum).

The aim is to construct an efficient algorithm for computation of the optimal regularization parameter within a regularization method for inverse problems. The regularization parameter is iteratively approximated by a Newton-type method, where the individual steps are carried out on locally refined meshes.

Analysis, solution and discretization techniques for boundary optimal control problems governed by the wave equation (B. Vexler with K. Kunisch)

The goal is to analyse the behaviour of fast optimization algorithms applied to Neumann and Dirichlet boundary optimal control problems governed by the wave equation. Moreover, the discretization of these problems using space-time finite element methods will be investigated.

Portfolio optimization

Portfolio optimization requires solving a Hamilton Jacobi Bellman equation which is of the type of a singular diffusion equation with constraints on the gradient. Such problems will be analyzed both from the analytical as well as a numerical and algorithmic perspective. Special attention will be paid to the higher dimensional cases.

Optimal control of mixing of fluids

An optimal control frame work for "optimal mixing" of fluids is envisioned. Control parameters can be the injection speed or geometric variables.

Dr. Roland Griesse

Introduction

Dr. Roland Griesse conducts research in the field of optimal control of coupled systems of partial differential equations (PDEs). His interests extend from the mathematical analysis to the numerical solution of control- and state-constrained problems. The most recent application areas cover in particular magnetohydrodynamic (MHD) as well as crystal growth phenomena. The stability and perturbation analysis of optimal solutions under parameter perturbations, which is also essential to prove the convergence of iterative optimization methods of SQP type, continues to be another of his areas of expertise.

From October 2006 through the end of February 2007, Dr. Griesse held a full (W3) temporary replacement professorship at Chemnitz University of Technology. In June 2007, Dr. Griesse received an offer from Dresden University of Technology for a permanent W2 professorship (Numerical Methods in Optimal Control). In August 2007, he received an offer from RWTH Aachen for a permanent W2 professorship (Continuous Optimization) and an offer from TU Chemnitz for a permanent W3 professorship (Numerics of PDEs). He accepted the offer from TU Chemnitz in November 2007 and is planning to move to the new position in March 2008.

Scientific Achievements 2007

In 2007, Dr. Griesse has worked on the following topics:

Sufficient Second-Order Optimality Conditions and Convergence Analysis for SQP Methods for Mixed Constrained Optimal Control Problems
Cooperation with Dr. Arnd Rösch and Dipl.-Math. Nataliya Metla
In 2007, we were able to prove local quadratic convergence of the SQP method applied to semilinear problems with linear constraints. A publication [7] has been submitted.

Active Set Methods for Portfolio Optimization Problems
Cooperation with Prof. Dr. Karl Kunisch and Dr. Jörn Sass
Portfolio optimization problems with proportional transaction costs can be formulated as complementarity systems. In this cooperation, we are devising and analyzing fast schemes of active-set type for their numerical solution. A publication [9] which deals with a prototypical problem has been submitted.

Semismooth Newton Methods for Inverse Problems with Sparsity Constraints
Cooperation with Dr. Dirk Lorenz, University of Bremen
Sparsity constraints in inverse problems lead to formulations involving the space of ℓ_1 sequences. We analyze the semismooth Newton method in this context, see publication [8].

Optimal Control of Stefan Problems
A joint FWF project in this area, together with Prof. Dr. Karl Kunisch, has been approved for funding in June 2007. DI Martin Bernauer was hired and began his work in this project in August 2007. So far, he investigated and implemented discontinuous Galerkin Runge-Kutta schemes for the numerical solution of the level-set equation, which will be used to describe the liquid/solid interface for the Stefan problem.

Scientific Cooperations

Internal

1) Prof. Dr. Karl Kunisch, Research Group "Optimization and Optimal Control", RICAM
2) Dr. Marco Discacciati, Research Group "Computational Methods for Direct Field Problems", RICAM, now Ecole Polytechnique Fédéral de Lausanne (EPFL)
3) PD Dr. Arnd Rösch, Research Group "Inverse Problems", RICAM, now University of Duisburg-Essen
4) Dr. Jörn Sass, Research Group "Financial Mathematics", RICAM
5) Dipl.-Math. Nataliya Metla, Research Group "Inverse Problems", RICAM
6) Martin Bernauer, Johannes Kepler University Linz, Austria

External

1) Dr. Juan Carlos de los Reyes, Quito, Ecuador
2) Dr. Martin Weiser, ZIB Berlin, Germany
3) Dr. Moritz Diehl, Katholieke Universiteit Leuven, Belgium
4) Ao. Prof. Stefan Volkwein, University of Graz, Austria
5) Prof. Dr. Axel Voigt, TU Dresden, Germany
6) Prof. Dr. Ekkehard Sachs, University of Trier, Germany
7) Dr. Dirk Lorenz, University of Bremen, Germany
8) Prof. Jacek Gondzio, University of Edinburg, UK
9) Dr. Daniel Wachsmuth, TU Berlin, Germany

Participation at Conferences, Scientific Visits and Talks

Conferences and Invitations for Colloquium Talks

1) January 5, 2007 Colloquium Talk at Dresden University of Technology, Germany
2) January 12, 2007 Colloquium Talk at RWTH Aachen, Germany
3) January 18, 2007 Colloquium Talk at Chemnitz University of Technology, Germany
4) February 9, 2007 Colloquium Talk at University of Basel, Switzerland
5) February 11-17, 2007 Workshop on "Control of Free Boundaries", Oberwolfach, Germany
6) March 7-9, 2007 Workshop on "Optimization Methods, Approximation and Adaptivity in PDE-Constrained Optimization, RICAM, Linz, Austria
7) March 14, 2007 Colloquium Talk at University of Edinburgh, UK
8) April 16-20, 2007 Workshop on "Optimization and Differential Equations", UAA, Aguascalientes, Mexico
9) May 23, 2007 Colloquium Talk at Chemnitz University of Technology, Germany
10) June 12, 2007 Colloquium Talk at Kaiserslautern University of Technology, Germany
11) June 15, 2007 Colloquium Talk at University of Trier, Germany
12) July 6, 2007 Colloquium Talk at University of Regensburg, Germany
13) July 16-20, 2007 ICIAM Zurich, Switzerland
14) July 23-27, 2007 IFIP Krakow, Poland
15) September 10-14, ENUMATH Graz, Austria
16) September 17-21, Plenary Presentation at the Czech-French-German Conference on Optimization, Heidelberg, Germany
17) September 20-21, SFB 609 Colloquium, Schmochtitz, Germany

Activities as Organizer

July 16-20, 2007 Co-organization of a minisymposium on *PDE-Constrained Optimization: Numerical Analysis and Scientific Computing* (together with Prof. Dr. Arnd Rösch, University of Duisburg-Essen, Germany)

Scientific Visits

1) March 12-16, 2007 University of Edinburgh (cooperation with Prof. Jacek Gondzio)
2) April 16-20, 2007 Universidad Autónoma de Aguascalientes (UAA), Aguascelientes, Mexico (invited by Prof. Jorge Macías-Diaz), held a short course on "Optimal Control of Linear Elliptic Partial Differential Equations"
3) June 13-15, 2007 University of Trier (cooperation with Prof. Ekkehard Sachs)
4) June 18-22, 2007 University of Graz (cooperation with Ao. Prof. Stefan Volkwein and Prof. Karl Kunisch)
5) October 18, University of Graz (cooperation with Prof. Karl Kunisch)
6) October 29-November 2, 2007 TU Berlin (cooperation with Dr. Daniel Wachsmuth)
7) November 12-16, 2007 University of Duisburg-Essen (cooperation with Prof. Arnd Rösch and Nataliya Metla)

Scientific Talks

1) "Analytical and Numerical Treatment of Optimal Control Problems in Magnetohydrodynamics" (Dresden University of Technology, Germany)
2) "From Finite-Dimensional Optimization to Optimal Control" (RWTH Aachen, Germany)
3) "Numerical Methods in PDE-Constrained Optimization" (Chemnitz University of Technology, Germany)
4) "Numerical Methods for Large-Scale Optimal Control Problems" (University of Basel, Switzerland)
5) "Control Issues in Magnetohydrodynamics" (Oberwolfach, Germany)
6) "Optimal Boundary Control of Phase Transitions in a Crystal Growth Process" (Workshop RICAM, Linz, Austria)
7) "Optimal Control Challenges in Magnetohydrodynamics" (University of Edinburgh, UK)
8) "Optimal Control Challenges in Magnetohydrodynamics" (UAA, Aguascalientes, Mexico)
9) "Multi-Field Problems in Magnetohydrodynamics and their Optimal Control" (Chemnitz University of Technology, Germany)
10) "Stability and Sensitivity for Optimization Problems with Partial Differential Equations" (Kaiserslautern University of Technology, Germany)
11) "The SQP Method for Optimal Control Problems with Mixed Control-State Constraints" (University of Trier, Germany)
12) "Optimal Control Challenges in Magnetohydrodynamics" (University of Regensburg, Germany)
13) "Mathematical Methods in MHD Flow Control" (ICIAM Zurich, Switzerland)
14) "KKT Systems Arising in Optimal Control of Magnetohydrodynamics" (ICIAM Zurich, Switzerland)
15) "Update Strategies for Perturbed Nonsmooth Equations" (IFIP Krakow, Poland)
16) "An SQP Method for Semilinear Optimal Control Problems with Mixed Constraints" (ENUMATH Graz, Austria)
17) "Stability and Sensitivity Analysis in PDE-Constrained Optimization" (Czech-French-German Conference on Optimization, Heidelberg, Germany), Plenary Presentation

Publications 2007

Appeared

[1] K. Brandes and R. Griesse, Quantitative Stability Analysis of Optimal Solutions in PDE-Constrained Optimization, Journal of Computational and Applied Mathematics (JCAM), 206(2), p.809-826, 2007

[2] R. Griesse, B. Vexler, Numerical Sensitivity Analysis for the Quantity of Interest in PDE-Constrained Optimization, SIAM Journal on Scientific Computing (SISC), 29(1), p.22-48, 2007

[3] R. Griesse, A.J. Meir, K. Kunisch, Control Issues in Magnetohydrodynamics, in: Control of Free Boundaries, Mathematisches Forschungsinstitut Oberwolfach, Report No. 8/2007, p.20-23, 2007

Accepted

[4] R. Griesse, T. Grund, D. Wachsmuth, Update Strategies for Perturbed Nonsmooth Equations, accepted for publication in: Optimization Methods and Software (OMS), 2007

[5] R. Griesse, M. Weiser, On the Interplay Between Interior Point Approximation and Parametric Sensitivities in Optimal Control, accepted for publication in: Journal of Mathematical Analysis and Applications (JMAA), 2007

Submitted

[6] R. Griesse, D. Wachsmuth, Sensitivity Analysis and the Adjoint Update Strategy for Optimal Control Problems with Mixed Control-State Constraints, submitted, 2007

[7] R. Griesse, N. Metla, A. Rösch, Local Quadratic Convergence of SQP for Elliptic Optimal Control Problems with Mixed Control-State Constraints, submitted, 2007

[8] R. Griesse, D. Lorenz, A Semismooth Newton Method for Tikhonov Functionals with Sparsity Constraints, submitted, 2007

[9] R. Griesse, K. Kunisch, A Semismooth Newton Method for Solving Elliptic Equations with Gradient Constraints, submitted, 2007

[10] R. Griesse, A.J. Meir, Modeling of an MHD-Free Surface Problem Arising in CZ Crystal Growth, submitted, 2007

Dr. Xiliang Lu

Scientific Achievements 2007

Since the start in August 2007, the field of activity has been the treatment of optimal control problem for the two phases fluid. Consider an open bounded domain which is occupied by two immiscible incompressible fluid, the motion of fluid satisfies the Navier-Stokes equation on each sub-domain which occupied by one fluid, and interface condition on the interface.

For the case of governing equation without surface tension, and only bodyforce control available, existence for the optimal control problem was established by a compensated compactness argument.

Activities

Scientific Talks

A Sequential Regularization Formulation for Navier-Stokes Equations, 2007 Sep. 05, RICAM.

Other Activities

Lipschitz Lectures at Hausdorff Institute for Mathematics, 2007 Nov. 26 - Dec. 11, Bonn, Germany.

Dr. Boris Vexler

Introduction

The research area of Dr. Boris Vexler is the development and analysis of efficient numerical methods for solution of optimization problems governed by partial differential equations. He works on the development of problem-adjusted discretization and solution concepts based on a priori and a posteriori error analysis. The fields of applications are fluid dynamics, chemical reaction systems, and multidimensional reactive flows.

Scientific Achievements in 2007

In 2007, Dr. Vexler has worked on the following topics:
1) A priori error estimates for space-time finite element discretization of parabolic optimal control problems (in cooperation with D. Meidner). We developed a priori error analysis for finite element discretization of optimal control problems governed by linear parabolic equations, see [10,11]. The space discretization of the state variable was done using usual conforming finite elements, whereas the time discretization was based on discontinuous Galerkin methods. For different types of control discretizations we provided error estimates of optimal order with respect to both space and time discretization parameters. Our work on this was divided into two parts: In the first part [10] we developed some stability and error estimates for space-time discretization of the state equation and provided error estimates for optimal control problems without control constraints. In the second part [11] the techniques and results of the first part were used to develop a priori error analysis for optimal control problems with pointwise inequality constraints on the control variable.

2) Adaptive finite elements for elliptic optimization problems with control constraints (in cooperation with W. Wollner). We developed a posteriori error estimates for finite element discretization of elliptic optimization problems with pointwise inequality constraints on the control variable, see [9]. We derived error estimators for assessing the discretization error with respect to the cost functional as well as with respect to a given quantity of interest. These error estimators provide quantitative information about the discretization error and guide an adaptive mesh refinement algorithm allowing to substantially save in degrees of freedom.

3) Efficient computation of Tikhonov regularization parameter by goal-oriented adaptive discretizations (in cooperation with A. Griesbaum and B. Kaltenbacher). We developed an efficient numerical algorithm for determining the Tikhonov parameter in regularization of inverse problems using adaptive finite element methods, see [12]. This algorithm is an inexact Newton's method for solution of the one-dimensional equation coming from the Morozov's discrepancy principle. The precision requirements for fast convergence as well as for the stopping criterion are based on a posteriori error estimates for the discretization error with respect to the norm of the least-squares residual as well as with respect to its derivative.

4) A posteriori error estimation and adaptivity for optimal control problems with state constraints (in cooperation with O. Benedix). Within the joint FWF-DFG project “Numerical analysis and discretization strategies for optimal control problems with singularities” (Th. Apel, A. Rösch, B. Vexler) we developed a posteriori error estimators for optimal control problems with pointwise inequality constraints on the state variable. The corresponding publication is in preparation.

Activities as organizer

1) Workshop “Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen”, SPP 1253 and RICAM, 2007 (joint with Th. Apel und A. Rösch)

2) Minisymposium "Numerical Methods in PDE-constrained optimization problems" at DMV-Jahrestagung 2007 (joint with D. Wachsmuth and M. Hinze)

3) Minisymposium "Numerical Methods for Optimization with PDE Constraints" at SIAM Conference on Control and Its Applications, San Francisco 2007 (joint with A. Rösch)

Teaching

Summer-Semester 2007 Compact Course "Adaptive Finite Element Methods", University of Graz, Austria

Scientific Cooperations

Internal
1) Prof. Dr. Karl Kunisch, Research Group "Optimization and Control", RICAM
2) Dr. Roland Griesse, Research Group "Optimization and Control", RICAM
3) Olaf Benedix, Research Group "Optimization and Control", RICAM
4) PD Dr. Arnd Rösch, Research Group "Inverse Problems", RICAM
5) Dr. Phillip Kügler, Research Group "Inverse Problems", RICAM

External
1) Prof. Dr. Rolf Rannacher, University of Heidelberg, Germany
2) Prof. Dr. Roland Becker, University of Pau, France
3) Prof. Dr. Thomas Apel, Universität der Bundeswehr München, Germany
4) Prof. Dr. Barbara Kaltenbacher, University of Stuttgart, Germany
5) Prof. Dr. Fredi Tröltzsch, Technical Universtity of Berlin, Germany
5) Ao. Prof. Dr. Alfio Borzi, University of Graz, Austria
6) Dr. Thomas Richter, MIT, USA
6) Dipl. Math. Dominik Meidner, University of Heidelberg, Germany
7) Dipl. Math. Michael Schmich, University of Heidelberg, Germany
8) Dipl. Math. Winnifried Wollner, University of Heidelberg, Germany
9) Dipl. Math. Anke Griesbaum, University of Heidelberg, Germany
10) Dipl. Math. Ira Neitzel, Technical Universtity of Berlin, Germany

Participation at Conferences, Scientific Visits and Talks

Conferences

- March 5-6, 2007: Spring School "Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen", SPP 1253 and RICAM
- March 6-9, 2007: Workshop "Optimierungsmethoden, Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen", SPP 1253 and RICAM
- March 26-30, 2007: DMV-Tagung, Berlin
- June 10-15, 2007: Workshop on Adaptive Numerical Methods for PDEs, Oberwolfach
- June 29 – July 1, 2007 : SIAM Conference on Control and Its Applications, San Francisco
- July 23 - 27, 2007: 23rd IFIP TC 7 Conference on System Modelling and Optimization, Krakow
- September 10 - 14, 2007: ENUMATH 2007, Graz

Scientific Visits

May 9-10, 2007University of Bayreuth (invited by Prof. Dr. Hans Josef Pesch)
May 14-18, 2007 University of Heidelberg (invited by Prof. Dr. Rolf Rannacher)
December 4-6, 2007 MOX, University of Milano (invited by Dr. Simona Perotto)

Scientific Talks

1. Adaptive Finite-Elemente-Verfahren für Optimierungsprobleme mit partiellen Differentialgleichungen, Technical University of Dresden, January 2007
2. Adaptive Finite-Elemente-Verfahren für Optimierungsprobleme mit partiellen Differentialgleichungen, RWTH Aachen, January 2007
3. Finite Elements and Adaptivity, Spring School at RICAM, March 2007
4. Adaptive finite elements for elliptic optimization problems with control constraints, SPP-workshop at RICAM, March 2007
5. Adaptivity for PDE-Constrained Optimization, University of Bonn, April 2007
6. Adaptive Finite Element Methods for Optimization Problems governed by PDEs, University of Stuttgart, May 2007
7. Adaptive Finite Element Methods for Optimization Problems governed by PDEs, University of Bayreuth, May 2007
8. Optimal Dirichlet Boundary Control of Elliptic and Parabolic Equations, University of Heidelberg, May 2007
9. Adaptive Finite Element Methods for Optimization Problems governed by PDEs, University of Duisburg, May 2007
10. Adaptivity for PDE-Constrained Optimization, Technical University of Chemnitz, May 2007
11. A Posteriori Error Estimation and Adaptivity for PDE-Constrained Optimization, Oberwolfach, June 2007
12. A Priori Error Estimates for Space-Time Finite Element Discretization of Parabolic Optimal Control Problems, San Francisco, June 2007
13. Adaptivity for PDE-Constrained Optimization, Technical University of Munich, July 2007
14. Optimal Control of the Convection-Diffusion Equation using Stabilized Finite Element Methods, Krakow, Poland, July 2007
15. A Priori Error Estimates for Space-Time Finite Element Discretization of Parabolic Optimal Control Problems, Graz, September 2007

Publications 2007

Appeared

[1] R. Griesse, B. Vexler "Numerical Sensitivity Analysis for the Quantity of Interest in PDE-Constrained Optimization", *SIAM Journal on Scientific Computing*, 29(1):22-48, 2007
[2] D. Meidner, B. Vexler "Adaptive Space-Time Finite Element Methods for Parabolic Optimization Problems", *SIAM Journal on Control and Optimization*, 46(1):116-142, 2007
[3] R. Becker, B. Vexler "Optimal Control of the Convection-Diffusion Equation using Stabilized Finite Element Methods", Numerische Mathematik, 106(3):349-367, 2007
[4] R. Becker, D. Meidner, and B. Vexler "Efficient Numerical Solution of Parabolic Optimization Problems by Finite Element Methods", *Optimization Methods and Software*, Vol. 22(5):813 - 833, 2007
[5] K. Kunisch, B. Vexler "Constrained Dirichlet Boundary Control in L^2 for a Class of Evolution Equations", *SIAM Journal Control and Optimization,* Vol. 46(5):1726 – 1753, 2007
[6] K. Kunisch, B. Vexler "Optimal Vortex Reduction for Instationary Flow Based on Translation Invariant Cost Functionals", *SIAM Journal Control and Optimization*, Vol. 46(4):1368 - 1397, 2007

[7] B. Vexler "Finite Element Approximation of Elliptic Dirichlet Optimal Control Problems", *Numerical functional Analysis and Optimization*, Vol. 28(7-8):957 – 973, 2007

Accepted:

[8] M. Schmich and B. Vexler "Adaptivity with Dynamic Meshes for Space-Time Finite Element Discretizations of Parabolic Equations", accepted for publication in *SIAM Journal on Scientific Computing*, 2007
[9] B. Vexler and W. Wollner "Adaptive Finite Elements for Elliptic Optimization Problems with Control Constraints", accepted for publication in *SIAM Journal Control and Optimization*, 2007
[10] D. Meidner and B. Vexler "A Priori Error Estimates for Space-Time Finite Element Discretization of Parabolic Optimal Control Problems. Part I: Problems without Control Constraints, accepted for publication in *SIAM Journal Control and Optimization*, 2007
[11] D. Meidner and B. Vexler "A Priori Error Estimates for Space-Time Finite Element Discretization of Parabolic Optimal Control Problems. Part II: Problems with Control Constraints, accepted for publication in *SIAM Journal Control and Optimization*, 2007

Submitted

[12] A. Griesbaum, B. Kaltenbacher, and B. Vexler "Efficient computation of the Tikhonov regularization parameter by goal oriented adaptive discretization", submitted, 2007

Olaf Benedix advised by Dr. Boris Vexler and Prof. Dr. Arnd Rösch

Scientific Achievements 2007

In 2007, the field of activity has been the treatment of elliptic optimal control problems which are governed by a semilinear state equation, and the presence of additional state constraints.
For the numerical solution of these problems an algorithm based on an active set method has been developed and implemented in the software package RoDoBo. To achieve a particularly effective solution strategy an error estimator for the error in the cost functional between the exact and the approximate solution has been derived analytically, and implemented in said package. Tests of the efficiency of the error estimator have been carried out. The corresponding publication, jointly with Dr. Boris Vexler, is in preparation.

Scientific Cooperations

Internal
Dr. Boris Vexler (Group Optimal Control)
Prof. Dr. Arnd Rösch (Group Inverse Problems), now University of Duisburg-Essen

External
Prof. Dr. Thomas Apel, UniBW Munich
Dieter Sirch, UniBw Munich
Thomas Flaig, UniBW Munich

Participation in Conferences, Scientific Visits and Talks

Conferences

- 1) March 5-9, 2007, Spring School and Workshop on "Approximation und Adaptivität bei Optimierungsproblemen mit partiellen Differentialgleichungen" at RICAM, Linz, Austria
- 2) April 26-27, 2007, 3rd Austrian Numerical Analysis Day at TU Wien, Austria,

- 3) June 25-26, 2007, Workshop on "Optimization with partial differential equations: structure exploiting algorithms, shape optimization and automatic differentiation" at Freudenstadt, Germany,
- 4) July 23-27, 2007, IFIP Conference on "System Modelling and Optimization", Krakow, Poland
- 5) October 4-5, 2007, DFG/SPP1253 annual meeting at Bad Honnef, Germany

Scientific Visits

November 5-8, 2007, UniBW Munich (invited by Prof. Dr. Thomas Apel)

Scientific Talks

1) Error estimation for state constrained elliptic optimal control problems, Krakow, July 2007
2) Error estimation for semilinear elliptic optimal control problems with state constraints, Bad Honnef, October 2007
3) A-posteriori-Fehlerschätzung für semilineare Optimalsteuerprobleme mit Zustandsbeschränkungen, Munich, November 2007

Other Activities

Publications 2007

In Preparation
O. Benedix and B. Vexler "A posteriori error estimation and adaptivity for elliptic optimal control problems with state constaints", in preparation, 2007

Martin Bernauer advised by Dr. Roland Griesse and Prof. Karl Kunisch

Scientific Achievements 2007

I finished my studies in applied mathematics at the Johannes Kepler University, Linz, in January 2007. The title of my diploma thesis was "A Robustification Approach in Unconstrained Optimization and its Applications in Optimal Control". I started working at RICAM on August 20th as research assistant within the project P19918, funded by FWF. This project is devoted to the optimal control of Stefan problems with constraints. Stefan problems are used to describe solidification processes. These phenomena are characterized by time-dependent partial differential equations on two- or three-dimensional domains that are not known a-priori, but are rather part of the solution. It is the goal of this project to control the so called moving boundary that describes the domain. Constraints on this moving boundary will also be considered.

Scientific Cooperations

Internal
Prof. Kunisch (Group "Optimization and Optimal Control")
Dr. Griesse (Group "Optimization and Optimal Control")

Participation at Conferences, Scientific Visits and Talk

Short Course on "Dynamic Optimization in Engineering and Nonlinear Model Predictive Control" by Prof. Diehl, (July 2nd – 7th, Linz, Austria)

Lipschitz Lecture on "Semi-smooth Newton methods for non-differentiable optimization problems" by Prof. Kunisch (November 26th - December 11th, Bonn, Germany)

Publications 2007

In Preparation

M. Bernauer and R. Griesse, "A Robustification Approach in Unconstrained Optimization"

Nataliya Metla advised by Dr. Roland Griesse and Prof. Dr. Arnd Rösch

see group "Inverse Problems"

4.8 GROUP "MATHEMATICAL IMAGING"

Group Leader:
Univ.-Prof. Dr. Otmar Scherzer

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Peter Elbau
Dr. Bastian Gebauer

Introduction by Group Leader Prof. Otmar Scherzer

The group "Mathematical Imaging" is relatively new and started with the appointment of Dr. Elbau and Dr. Gebauer joining RICAM on October 1st, 2006. Dr. Elbau was formerly at the ETH Zürich working in the group of Prof. G. Felder and Dr. Gebauer came from the group of Prof. M. Hanke (Mainz). The scope of this new group is the study of mathematical techniques for data acquisition and mathematical theory for image analysis. As mentioned in the proposal the research shares joint scientific interests with other working groups at RICAM, especially with the Inverse Problems and Analysis of Partial Differential Equations working groups. In his PhD thesis, Markus Grasmair from the Infmath Imaging group in Innsbruck has developed existence theory of non convex variational optimization problems in image analysis. The original motivation of this topic was to derive variational problems approximating evolution equations for which just viscosity solutions exist. If successful such an approach can be generalized to derive novel image analysis techniques for higher dimensional data, such as color image data or diffusion tensor imaging data in medicine. At the present research, when analyzing higher dimensional data, we are confronted with a paradox, that the variational optimization problems are know to attain a generalized solution but cannot be minimized efficiently, while the evolution equations can be solved relatively easily with explicit or semi implicit methods, but there is no solution theory available. To close the gap between non convex variational problems and associated PDEs is the core theme of work of Dr. Elbau. There several problems have to be tackled:

- A solution theory of evolutionary equations has to be derived. A very suitable approach has been discovered recently (joint work of Dr. Elbau with Prof. Dziuk (Freiburg) and the Infmath Imaging group in Innsbruck). We call it "Non Convex Semigroup Theory". The approach generalizes convex (linear and nonlinear) semigroup theory, and is based on employing variational relaxation techniques. We have made some success in this area recently, and shown that solutions can be well—defined, and could provide some analytical examples showing that there is in fact a relation to viscosity solutions of evolutionary equations.
- In order to proceed with the ideas of non-convex semigroups we will conduct further analytical studies on explicit solution of case examples of partial differential equations and non convex variational problems. Mathematically the topic of analytical solution is extremely challenging, and tedious calculations are necessary, to get more insight in the nature of such problems. However the analytical studies are necessary to derive adequate solution concepts of evolutionary equations.
- On the theoretical side the existence theory of non convex variational problems has to be extended and novel characterization of the energy functional based on the quasi-convex hull should be provided, using duality arguments or convex characterization arguments. Moreover, the results have to be generalized to general metric spaces.
- On the practical side the numerics of the evolution equations has to be developed. At the present status of research, based on our preliminary solution concept it is not even known what the terminology stability, consistency, and approximation properties actually mean. The appropriate numerical concepts are currently not available, although the efficient numerical implementation is quite straight forward for the models under considerations. We think that it is necessary to study this theory in combination with an appropriate analytical theory.

- Several applications have been investigated in the INFMATH group in Innsbruck, concerning filtering of vector valued data, ranging from Video enhancements and enhancement of compressed color images. Several other applications can be considered with variational techniques we developed as well, such as for instance Inverse Problems applications.

For the acquisition of medical images new tomography techniques have the potential of being less harmful for the patient and of showing a better contrast in soft tissue. In thermoacoustic tomography a body is illuminated by a short electromagnetic pulse. This leads to the emission of a sound wave, which is then measured to gain information on the interior of the body. Previous work in the Infmath Imaging in Innsbruck group has been done on reconstruction techniques and novel sensor configurations for this problem. The group leader has initialized an Austrian network on this topic and submitted an NFN draft proposal to the Austrian Science Foundation on thermoacoustic imaging where the Radon Imaging group is intended to actively participate. Several novel mathematical problems have been formulated already, and will also be considered by Dr. Gebauer at Radon. Thermoacoustic tomography is a long term project which has impact from medicine and experimental physics, and is considered a long term project within the research interests of Radon Imaging.

Dr. Gebauer also intends to further develop his successful work on sampling methods for inverse problems applications.

The group is also actively participating in the “bioimaging” semester and is organizing several events.

Dr. Peter Elbau

Scientific Work 2007

Dr. Peter Elbau analysed the non-convex semi-group solution for the mean curvature motion. To be able to analytically get solutions, the problem was restricted to axially symmetric initial conditions. Then the axially symmetric solution of the evolutionary equation can be explicitly given. On the other hand, it was possible to show that the minimisers of the relaxation of the corresponding non-convex functional, which we use for the construction of the semi-group solution, are axially symmetric, too. Thus, the minimisation problem reduced to an one-dimensional variational problem. Here, it could be proven that the associated Euler-Lagrange equations admit a solution. Moreover, the behaviour of the solution could be analytically estimated. Finally, it was possible to prove with this approach that for continuously differentiable, axially symmetric initial conditions, the non-convex semi-group solution coincides with the viscosity solution of the mean-curvature equation.

Encouraged by these results, he turned his attention to the non-convex semi-group theory for functionals over vector-valued functions. He investigated a few functionals which - in some sense – can be considered generalisations of non-convex regularisation functionals to vector valued data. Numerically, the solutions of the corresponding evolutionary equations show that they are reasonable filtering techniques. Peter Elbau recently discovered that in some cases, the filtering techniques do not behave as expected and is therefore now trying to modify them accordingly.

Invited Speaker

Journées de Metz 2007, 3.-5. Mai 2007, PDE and variational methods in image analysis
Special Semester on Quantitative Biology analyzed by Mathematical Methods, RICAM, 19.-23. November 2007, Workshop on Bioimaging II / PDEs

Dr. Bastian Gebauer

Scientific Achievements 2007

The research of Dr. Bastian Gebauer in the beginning of 2007 mainly concentrated on the sensitivity analysis of a parabolic-elliptic problem. Such problems appear in heat conduction or in the scattering of low-frequency electromagnetic waves, when the heat capacity resp. the electrical conductivity is positive in a part of the domain and zero in another part. The underlying partial differential equation is parabolic where the capacity is positive and elliptic where the capacity is zero. An initial condition is only meaningful on the part where the equation is parabolic and interface conditions are needed for the interface between the two parts. Up to now the derivation of such equations was purely formal and no results were known for the case when there is no sharp interface between the two parts but a continuous transition. B. Gebauer was able to show the well-posedness of the heat equation for general non-negative L-infinity capacities thus treating continuous interfaces as well as smooth transitions, and to give a rigorous justification to such parabolic-elliptic models by showing that the solutions depend continuously on the heat capacity even if that attains zero. Part of the results together with a previous work on parabolic-elliptic problems were presented on the AMS/MAA Joint Mathematics Meeting in New Orleans, Jan. 5-8, 2007. A preprint of a research paper covering the results has been published as a
Ricam report, the research paper has been published in Quart. Appl. Math. [2]. Also a related previously finished joint work of F. Frühauf, B. Gebauer and O. Scherzer on parabolic-elliptic problems has been published in 2007 as [1].

B. Gebauer has also attended the Workshop on Integral Equations and Shape Reconstruction devoted to Prof. Rainer Kress on the occasion of his 65th birthday, Göttingen, Germany, Jan. 19 – 20, 2007 and visited the group of Prof. Otmar Scherzer in Innsbruck, Jan. 29 – 30, 2007. In March 2007, B. Gebauer gave an invited talk at the Oberwolfach workshop on “Inverse Problems in Wave Scattering” about “Sampling methods for low-frequency electromagnetic imaging”. An extended abstract of the talk has been published in the series of Oberwolfach Reports. The ideas of the underlying research paper were already described in the annual report 2006; the paper itself has been accepted for publication in Inverse Problems [4].

Motivated by the above-mentioned Oberwolfach workshop was a joint work of B. Gebauer with N. Hyvönen (Helsinki University of Technology, Finnland) about the factorization method and irregular inclusions in electrical impedance tomography (EIT). Previous works on the factorization method for EIT relied on the fact that there is a sharp conductivity jump between the known background medium and the unknown inclusions. It was shown only recently that this jump might also be in one of the higher derivatives of the conductivity. Also the inclusions had to satisfy a certain boundary regularity. B. Gebauer and N. Hyvönen were now able to completely drop these assumptions and treat inclusions that are merely open sets (with connected complement) and inclusions with a smooth transition in the conductivity. A research paper including two-dimensional numerical examples has been published in Inverse Problems [3]. Continuing their constructive collaboration, B. Gebauer and N. Hyvönen are investigating the use of the Factorization Method for inclusions of mixed type in diffuse optical tomography.

B. Gebauer also developed a method to construct special sequences of electric potentials in impedance tomography that diverge on given subsets of a domain while staying bounded on others. These potentials are closely connected to the Factorization Method and they can be used to prove theoretical identificability results and to construct non-iterative reconstruction algorithms. He presented preliminary results during a visit at the University of Mainz, Germany, Jun. 11 – 15, 2007, and in an invited talk at the Conference on Applied Inverse Problems in Vancouver, Canada, Jun. 25 – 29, 2007. More advanced results were presented by him in an invited talk at the Workshop on Bioimaging II / PDEs in Linz, November 19 - 23, 2007 and in an invited talk at the Rhein-Main Arbeitskreis

Mathematics of Computation, Mainz, November 23, 2007. A research paper about these results is currently prepared.

B. Gebauer and Prof. Dr. O. Scherzer have also invented and studied a new hybrid imaging technique. The Austrian Academy of Sciences is currently investigating the possibility to utilize and patent this new technology. A research paper describing the new technique and showing first numerical results is in preparation.

Scientific Cooperations

Internal
Prof. Otmar Scherzer, University of Innsbruck, Austria and RICAM

External
Florian Frühauf, Department of Computer Science, University of Innsbruck, Austria
Prof. Martin Hanke-Bourgeois, Institute of Mathematics, Joh. Gutenberg University, Mainz, Germany
Nuutti Hyvönen, Institute of Mathematics, Helsinki University of Technology, Finland
Christoph Schneider, Institute of Mathematics, Joh. Gutenberg University, Mainz, Germany

Participations at Conferences, Scientific Visits and Talks

Conferences
- AMS-MAA Joint Mathematics Meeting, New Orleans, USA, 05.01.07 – 08.01.07. Invited Conference Talk: "Detecting Interfaces in a Parabolic-Elliptic Problem".
- Workshop on Integral Equations and Shape Reconstruction devoted to Prof. Rainer Kress on the occasion of his 65th birthday, Göttingen, Germany, 19.01.07 – 20.01.07.
- Inverse Problems in Wave Scattering, Oberwolfach, Germany, 04.03.07 –10.03.07. Invited Conference Talk: "Sampling methods for low-frequency electromagnetic imaging".
- Conference on Applied Inverse Problems 2007, Vancouver, Canada, 25.06.07 – 29.06.07. Invited Conference Talk: "Electric potentials with localized divergence properties".
- 6th International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, 16.07.07 – 20.07.07. Invited Conference Talk: "Sampling methods for low-frequency electromagnetic imaging".
- Workshop on Bioimaging II / PDEs, RICAM, Linz, Austria, 19.11.07 – 23.11.07. Invited Conference Talk: "Localized potentials in electrical impedance tomography".
- Rhein-Main Arbeitskreis Mathematics of Computation, Mainz, Germany, 23.11.07. Invited Conference Talk: "Localized potentials in electrical impedance tomography".

Scientific Visits
- INFMATH Imaging group, Innsbruck, 29.01.07 – 30.01.07.
- Institut für Mathematik, University of Mainz, Germany, 11.06.07 – 15.06.07. Invited Colloquium Talk: "Electric potentials with localized divergence properties".

Talks
Talks at conferences and during scientific visits are listed above.

Publications

Appeared
[1] F. Frühauf, B. Gebauer and O. Scherzer: Detecting interfaces in a parabolic-elliptic problem from surface measurements, *SIAM J. Numer. Anal.* 45 (2007) 810-836.

[2] B. Gebauer: Sensitivity analysis of a parabolic-elliptic problem, *Quart. Appl. Math.* 65 (2007) 591–604. (Preprint: RICAM Reports 2007-05, Johann Radon Institute, Linz, Austria, 2007.)

[3] B. Gebauer and N. Hyvönen: Factorization method and irregular inclusions in electrical impedance tomography, *Inverse Problems* 23 (2007) 2159-2170.

Accepted

[4] B. Gebauer, M. Hanke and C. Schneider: Sampling methods for low-frequency electromagnetic imaging, accepted for publication in *Inverse Problems*. (Extended abstract: *Oberwolfach Rep.* 13 (2007) 40-42.)

5. PUBLICATIONS 2007

This chapter contains the publications for the year 2007. The data is from "Akademis".

H. Niederreiter, A. Winterhof (2007) Exponential sums for nonlinear recurring sequences. Finite Fields and Their Applications, S. to appear. [Winterhof, A. (HauptautorIn)]
H. Aly, W. Meidl, A. Winterhof (2007) On the k-error linear complexity of cyclotomic sequences. Journal of Mathematical Cryptography, Bd. 1 (3). [Winterhof, A. (HauptautorIn)]
I. Shparlinski, A. Winterhof (2007) Quantum period reconstruction of noisy sequences. Information Processing Letters, Bd. 103 (6), S. 283-296. [Winterhof, A. (HauptautorIn)]
W. Meidl, A. Winterhof (2007) On the linear complexity profile of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, Bd. to appear. [Winterhof, A. (HauptautorIn)]
J. Gutierrez, A. Winterhof Exponential sums of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, S. to appear. [Winterhof, A. (HauptautorIn)]
S. Balasuriya, I. Shparlinski, A. Winterhof An average bound for character sums with some counter-dependent recurrence sequences. Rocky Mountain Journal, S. to appear. [Winterhof, A. (HauptautorIn)]
Kuijper, A. (2007) Deriving the Medial Axis with Geometrical Arguments for Planar Shapes. Pattern Recognition Letters, Bd. 28 (15), S. 2011-2018 . [Kuijper, A. (AlleinautorIn)]
Gebauer, B. (2007) Sensitivity analysis of a parabolic-elliptic problem. Quart. Appl. Math., Bd. 65 (3), S. 591-604 . [Gebauer, B. (AlleinautorIn)]
Gebauer, Bastian; Hyvönen, Nuutti (2007) Factorization method and irregular inclusions in electrical impedance tomography. Inverse Problems, Bd. 23 (5), S. 2159-2170 . [Gebauer, B. (HauptautorIn)]
Gebauer, Bastian; Hanke, Martin; Schneider, Christoph (2007) Sampling methods for low-frequency electromagnetic imaging. Inverse Problems, Bd. 015007, S. (18pp) . [Gebauer, B. (HauptautorIn)]
Massimo Fornasier, Holger Rauhut Recovery algorithms for vector valued data with joint sparsity constraints . SIAM Journal on Numerical Analysis. [Fornasier, M. (KoautorIn)]
S. Dahlke, Massimo Fornasier, H. Rauhut, G. Steidl, and G. Teschke (2007) Generalized coorbit theory, Banach frames, and the relation to alpha-modulation spaces . Proceedings of the London Mathematical Society. [Fornasier, M. (KoautorIn)]
S. Dahlke, Massimo Fornasier, T. Raasch, R. Stevenson and M. Werner (2007) Adaptive frame methods for elliptic operator equations: the steepest descent approach . IMA Journal of Numerical Analysis, Bd. 27 (4), S. 717−740 . [Fornasier, M. (KoautorIn)]
B. Hofmann, P. Math´e, and S. V. Pereverzev (2007) Regularization by projection: Approximation theoretic aspects and distance functions. J. Inv. Ill-Posed Problems, Bd. 15, S. 527–545. [Pereverzyev, S. (HauptautorIn)]
B. Hofmann, P. Math´e, and S. V. Pereverzyev (2007) Regularization by projection: Approximation theoretic aspects and distance functions. J. Inv. Ill-Posed Problems, Bd. 15, S. 527-545. [Pereverzyev, S. (HauptautorIn)]
Klann, E.; Kuhn, M.; Lorenz, D.A.; Maass, P.; Thiele, H. (2007) Shrinkage versus deconvolution. Inverse Problems, Bd. 23 (5), S. 2231-2248. [Klann, E. (KoautorIn)]
M. Burger, E. Resmerita, L.He (2007) Error estimation for Bregman iterations and inverse scale space methods in image restoration. Computing, Bd. 81. [Resmerita, E. (HauptautorIn)]
E. Resmerita, H. Engl, A.N. Iusem (2007) The expectation-maximization algorithm for ill-posed integral equations: a convergence analysis. Inverse Problems, Bd. 23. [Resmerita, E. (HauptautorIn)]
E. Resmerita, R.S. Anderssen (2007) Joint additive Kullback-Leibler residual minimization and regularization for linear inverse problems. Mathematical Methods in the Applied Sciences, Bd. 30.

[Resmerita, E. (HauptautorIn)]
J. R. Sendra, J. Schicho (2007) Special Issue on Algebraic Curves (foreword). AAECC, Bd. 18 (1/2), S. 1-2. [Schicho, J. (HerausgeberIn)]
J. G. Alcazar, J. Schicho, J. R. Sendra (2007) A Delineability-based Method for Computing Critical Sets of Algebraic Surfaces. J. Symb. Comp., Bd. 42 (6), S. 678-691. [Schicho, J. (KoautorIn)]
S. Widder, J. Schicho, P. Schuster (2007) Dynamic patterns of gene regulation I: simple two-gene systems. J. Theoret. Bio., Bd. 246, S. 395-419. [Schicho, J. (KoautorIn)]
C. Haase, J. Schicho Lattice Polygons and the Number 2i+7. Amer. Math. Monthly. [Schicho, J. (HauptautorIn)]
G. Landsmann, P. Mayr, J. Schicho (2007) A Topological Property of Polynomial Functions on GL(2,R). Aequat. Math., Bd. 73 (1-2), S. 71-77. [Schicho, J. (HauptautorIn)]
H.-C. Graf v. Bothmer, O. Labs, J. Schicho, C. van de Woestijne (2007) The Cases-Alvero conjecture for infinitely many degrees. J. Algebra, Bd. 316 (1), S. 224-230. [Schicho, J. (KoautorIn)]
S. Kindermann, R. Ramlau (2007) Surrogate Functional and Tresholding for Inverse Interface problems. J. of Inv. and Ill-Posed Problems, Bd. 15 (4), S. 387-402. [Ramlau, R. (HauptautorIn)]
R. Ramlau, G. Teschke (2007) An Iterative Algorithm for Nonlinear Inverse Problems with Joint Sparsity Constraints in Vector Valued Regimes and an Application to Color Image Inpainting. Inverse Problems, Bd. 23 (5), S. 1851-1870. [Ramlau, R. (HauptautorIn)]
L. Justen, R. Ramlau A General Framework for Soft – Shrinkage with Applications to Blind Deconvolution and Wavelet Denoising. Applied and Computational Harmonic Analysis. [Ramlau, R. (HauptautorIn)]
W. Meidl, A. Winterhof (2007) On the linear complexity profile of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, Bd. 13 (3), S. 628-634. [Winterhof, A. (HauptautorIn)]
I. Shparlinski, A. Winterhof On the number of distances between the coordinates of points on modular hyperbolas. Journal of Number Theory, S. to appear. [Winterhof, A. (HauptautorIn)]
H. Albrecher, J. Hartinger (2007) A risk model with multi-layer divident strategy. North American Actuarial Journal, Bd. 11 (2), S. 43-64. [Albrecher, H. (HauptautorIn)]
H. Albrecher, J. Hartinger (2007) Author´s Reply to Discussions of the Paper. North American Actuarial Journal, Bd. 11(4). [Albrecher, H. (HauptautorIn)]
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H. Albrecher, P. Mayer, W. Schoutens (2007) General lower bounds for arithmetic Asian option prices. Applied Mathematical Finance. [Albrecher, H. (KoautorIn)]
S. Kindermann, P. Mayer, H. Albrecher, H. Engl Identification of the local speed function in a Levy model for option pricing. Journal of Integral Equations and Applications. [Albrecher, H. (KoautorIn)]
Albrecher, H. The next step: CDO´s for catastrophe risks. WILMOTT. [Albrecher, H. (AlleinautorIn)]
Griesse, Roland; Grund, Thomas; Wachsmuth, Daniel (2008) Update Strategies for Perturbed Nonsmooth Equations. Optimization Methods and Software. [Griesse, R. (HauptautorIn)]
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Identification of the local speed function in a Levy model for option pricing. Journal of Integral Equations and Applications. [Engl, H. (HauptautorIn)]
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Problems by Finite Element Methods. Optimization Methods and Software, Bd. 22 (5), S. 813 - 833. [Vexler, B. (HauptautorIn)]
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J.K. Kraus, S.D. Margenov, J. Synka (2008) On the multilevel preconditioning ofCrouzeix-Raviart elliptic problems. Numer. Linear Algebra Appl. [Kraus, J. (HauptautorIn)]
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F. Bauer, A. Kuijper, and L. Muresan (2007) International Workshop on Image Analysis in the Life Sciences; Theory and Applications Book of abstraxcts. . [Kuijper, A. (KoherausgeberIn)]
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Y. Zhou, A. Kuijper, B. Heise, L. He (15.06.2007) Cell Segmentation Using the Level Set Method.

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Huber, Martin; Schöberl, Joachim; Sinwel, Astrid; Zaglmayr, Sabine (15.10.2007) Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach. Bericht-Nr. 2007-22; RICAM: Linz . [Huber, M. (HauptautorIn); Sinwel, A. (KoautorIn); Zaglmayr, S. (KoautorIn)]
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S. Repin, S. Tomar (21.12.2007) A posteriori error estimates for nonconforming approximation of elliptic problems based on Helmholtz type decomposition of the error. Bericht-Nr. 2007-41; RICAM, Austrian Academy of Sciences:. [Tomar, S. (HauptautorIn)]
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I. Georgiev, J. Kraus, S. Margenov, J. Schicho (15.12.2007) Locally optimized MIC(0) preconditioning of Rannacher-Turek FEM systems. Bericht-Nr. 2007-32; RICAM: Linz. [Kraus, J. (HauptautorIn); Schicho, J. (HauptautorIn)]
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D. Gomez, A. Winterhof Character sums of nonlinear recurrence sequences with Dickson polynomials., Finite Fields and Applications; Melbourne, S. to appear. [Gomez, D. (HauptautorIn); Winterhof, A. (HauptautorIn)]
N. Brandstätter, A. Winterhof Subsequences of Sidelnikov sequences., Finite Fields and Applications; Melbourne, S. to appear. [Brandstätter, N. (HauptautorIn); Winterhof, A. (HauptautorIn)]
H. Niederreiter, A. Winterhof (01.12.2007) On the structure of inversive pseudorandom number generators. In: al., S. Boztas et (Hrsg.), AAECC 17; Bangalore, S. 208-216. [Winterhof, A. (HauptautorIn)]
, A.Kuijper (15.06.2007) Image Processing with Geometrical and Variational PDEs., 31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07 (31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07); Schloss Krumbach: OCG, S. 89--96 . [Kuijper, A. (AlleinautorIn)]
Kuijper, A. (15.06.2007) Image analysis using p-Laplacian and geometrical PDEs., 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007) (6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007)), S. 157 . [Kuijper, A. (AlleinautorIn)]
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, A.Kuijper (15.06.2007) p-Laplacian driven image processing., 14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007) (14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007)) In Reihe: Proceedings ICIP - IEEE: IEEE, S. Vol. V, pages 257--260 . [Kuijper, A. (AlleinautorIn)]
Kuijper, A. (15.06.2007) Qualitative and Quantitative Behaviour of Geometrical PDEs in Image Processing., LNCS 4843 (8th Asian Conference on Computer Vision, ACCV 2007 (Tokyo, Japan, Nov. 18-22, 2007)) In Reihe: LNCS: Springer, S. 230--239 . [Kuijper, A. (AlleinautorIn)]
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Kraus, J.; Tomar, S. (15.11.2007) A multilevel method for discontinuous Galerkin approximation of three-dimensional elliptic problems. In: Langer, U.; Discacciati, M.; Keyes, D.; Widlund, O.; Zulehner, W. (Hrsg.), Domain Decomposition Methods in Science and Engineering XVII (17th International Conference on Domain Decomposition Methods, St. Wolfgang/Strobl, Austria) In Reihe: Lecture Notes in Computational Science and Engineering, vol. 60; Heidelberg, 2008: Springer, S. 155-164. [Kraus, J. (HauptautorIn); Tomar, S. (HauptautorIn)]
I. Georgiev, J.K. Kraus, S.D. Margenov (15.06.2008) Multilevel preconditioning of rotated trilinearnon-conforming finite element problems., Large Scale Scientific Computing (LSSC 2007) In Reihe: Lecture Notes in Computer Science (LNCS); Berlin, Heidelberg: Springer. [Kraus, J. (HauptautorIn)]
J.K. Kraus, D. Lucas (15.06.2008) A fixed-grid finite element algebraic multigrid approach for interface shape optimization governed by 2-dimensional magnetostatics., Large Scale Scientific Computing (LSSC 2007) In Reihe: Lecture Notes in Computer Science (LNCS); Berlin, Heidelberg: Springer. [Kraus, J. (HauptautorIn)]

Vorträge/Posterpräsentationen:

Sinwel, Astrid (26.09.2007) Mixed Finite Elements for Linear Elasticity. Posterpräsentation: Chemnitzer FEM Symposium, Chemnitz/GERMANY. [Sinwel, Astrid]
Sinwel, Astrid (18.05.2007) Mixed Finite Element Methods for Elasticity. Posterpräsentation: HOFEM (TU München)/GERMANY. [Sinwel, Astrid]
Anguige, Keith (23.10.2007) Modelling spontaneous aggregation of biological cells. Posterpräsentation: RICAM Evaluation, RICAM, Linz/AUSTRIA. [Anguige, Keith]
T. Beck, J. Schicho (23.10.2007) Parametrization of Algebraic Varieties. Posterpräsentation: RICAM evaluation, Linz/AUSTRIA. [Beck, Tobias; Schicho, Josef]
Arning, Kattrin (03.02.2007) Inverse Problems related with Ion Channels. Posterpräsentation: IX. Annual Linz Winter Workshop, Linz/AUSTRIA. [Arning, Kattrin]
Hahn, M. (15.06.2007) MCMC estimation of Markov switching models. Posterpräsentation: BISP5, Valencia/SPAIN. [Hahn, Markus]
Sinwel, Astrid (17.01.2007) Tangential Continuous Displacement and Normal-Normal Continuous Stress Mixed Finite Elements for Linear Elasticity. Vortrag: Workshop on Numerical Analysis for PDEs, Concepcion/CHILE. [Sinwel, Astrid]
Sinwel, Astrid (30.10.2007) Mixed Finite Elements for Linear Elasticity. Vortrag: Applied Math Seminar, University of Delaware/UNITED STATES. [Sinwel, Astrid]
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Schicho, J. (29.07.2007) Constrution of Rational Points on Rational Surfaces, Arithmetic and Algebraic Geometry. Vortrag: Clay Summer School, Goettingen/GERMANY. [Schicho, Josef]
L. He, T.C. Chung, S. Osher, T. Fang, P. Speier (18.09.2007) MR Image Reconstruction by Using the Iterative Refinement. Vortrag: University of Bretagne Sud, Vannes/FRANCE. [He, Lin]
Anguige, Keith (20.09.2007) A one-dimensional model of cell diffusion and aggregation, incorporating volume filling and cell-to-cell adhesion. Vortrag: Slovak-Austrian Mathematical Congress (ÖMG/JSMF), Podbanske/SLOVAKIA (Slovak Republic). [Anguige, Keith]
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fornasier, Massimo (12.11.2007) Mathematical imaging in visual art restoration. Vortrag: SCCH 2007: Scientific Computing and the Cultural Heritage IWR Workshop, Heidelberg/GERMANY . [Fornasier, Massimo]
Constantinescu, Corina (06.07.2007) Asymptotic results for the ruin probability in Sparre Andersen

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Beck, T. (16.08.2007) Formal Desingularization of Surface in P^3. Vortrag: Computational Algebra Seminar, School of Mathematics and Statistics, University of Sydney, Sydney/AUSTRALIA. [Beck, Tobias]
Beck, T. (22.05.2007) Three Problems in the Context of Formal Desingularization. Vortrag: Workshop on Resolution of Algebraic Varieties, Nove Hrady/CZECH REPUBLIC. [Beck, Tobias]
Beck, T. (10.09.2007) Formal Desingularization of Surfaces - Jung's Method Revisited. Vortrag: Workshop on Computational Methods for Algebraic Spline Surfaces, Strobl am Wolfgangssee/AUSTRIA. [Beck, Tobias]
Wolfram, Marie-Therese (10.10.2007) Numerical Simulation of Ion Channels using Finite Elements. Vortrag: Workshop on Ion Channels, Linz/AUSTRIA. [Wolfram, Marie-Therese]
Renaud, Jean-Francois (05.12.2007) Spectrally negative Levy risk processes with tax and dividends. Vortrag: Swiss Probability Seminar/SWITZERLAND. [Renaud, Jean-Francois]
Hahn, M. (19.09.2007) Semi-continuous MCMC estimation of continuous time Markov switching models. Vortrag: Statistiktage 2007 (IFAS, ÖSG), Linz/AUSTRIA. [Hahn, Markus]
Hahn, M. (22.04.2007) MCMC Methods for Parameter Estimation in Multidimensional Continuous Time Markov Switching Models. Vortrag: International Workshop on Computational and Financial Econometrics, Genf/SWITZERLAND. [Hahn, Markus]
Sini, M. (25.06.2007) Reconstruction of complex obstacles from farfield data. Vortrag: AIP/CANADA. [Sini, Mourad]
Sincich, Eva (28.06.2007) Lipschitz stability for the inverse Robin problem. Vortrag: AIP (Applied Inverse Problems)/CANADA. [Sincich, Eva]
Sincich, Eva (14.08.2007) Stability and reconstructions for inverse corrosion problems. Vortrag: ISAAC 2007/TURKEY. [Sincich, Eva]
Fonte, Massimo (15.08.2007) Case study of solutions for the Camassa-Holm equation. Vortrag: ISAAC 2007, Ankara/TURKEY. [Fonte, Massimo]
Fonte, Massimo (22.06.2007) Conservative and Dissipative solutions of the Camassa Holm Equation. Vortrag: Fifth meeting “Hyperbolic Conservation Laws: Recent Results and Research Perspectives, Trieste/ITALY. [Fonte, Massimo]
Sincich, Eva (12.04.2007) Determination of boundary terms and inverse scattering. Vortrag: SFB Seminar, Strobl,/AUSTRIA. [Sincich, Eva]
Sini, M. (18.07.2007) Reconstruction of complex obstacles from Maxwell farfield data. Vortrag: 6th International Congress on Industrial and Applied Mathematics/SWITZERLAND. [Sini, Mourad]
Sini, M. (22.09.2007) Making obstacle appear more (or less) visible from exterior data. Vortrag: The 8th International Workshop on Mathematical Methods in Scattering Theory and Biomedical Engineering/GREECE. [Sini, Mourad]
Sini, M. (17.12.2007) How to make interfaces appear more (or less) visible from exterior measurements?. Vortrag: ENIT/TUNISIA. [Sini, Mourad]
Resmerita, E. (08.01.2007) Convergence rates for non-quadratic regularization of nonlinear inverse problems. Vortrag: AMS-MAA Joint Mathematics Meeting, New Orleans/UNITED STATES . [Resmerita, Elena]
Resmerita, E. (19.07.2007) The EM algorithm for PET: A regularization approach. Vortrag: 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007),, Zuerich/SWITZERLAND . [Resmerita, Elena]
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Resmerita, E. (05.07.2007) A proximal method for image restoration: Error estimation. Vortrag: Joint EUROPT-OMS Conference 2007, Prague/CZECH REPUBLIC . [Resmerita, Elena]
Putschögl, Wolfgang (06.09.2007) Optimal Consumption and Investment under Partial Information. Vortrag: Operations Research 2007, Saarbrücken/GERMANY. [Putschögl, Wolfgang]
Putschögl, Wolfgang (20.09.2007) Optimal Investment Under Dynamic Risk Constraints and Partial Information. Vortrag: Workshop and Mid-Term Conference on Advanced Mathematical Methods for Finance (TU Wien), Vienna/AUSTRIA. [Putschögl, Wolfgang]
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Ramlau, Ronny (02.03.2007) New regularization approaches for tomography. Vortrag: International Workshop on Image Analysis in the Life Sciences, Linz/AUSTRIA. [Ramlau, Ronny]
Sass, J. (18.01.2007) Optimal portfolio policies under transaction costs. Vortrag: Mathematics Department Colloquium, Vancouver/CANADA. [Saß, Jörn]
Hahn, M. (11.02.2007) Projekt Finanzmathematik 1. Vortrag: Projektwoche Angewandte Mathematik (Stiftung Talente), Zell an der Pram/AUSTRIA. [Hahn, Markus]
Ramlau, Ronny (30.04.2007) Regularization of Inverse Problems using Sparsity Constraints – Analysis and Applications. Vortrag: RICAM Kuratorium Meeting, Linz/AUSTRIA. [Ramlau, Ronny]
Brandstätter, Nina (20.04.2007) k-Error Linear Complexity of Generalisations of Sidelnikov Sequences. Vortrag: International Workshop on Coding and Cryptography, Versailles/FRANCE. [Brandstätter, Nina]
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Brandstätter, Nina (05.03.2007) Pseudorandom Number Generators and Charactersums. Vortrag: PhD Defense, Linz/AUSTRIA. [Brandstätter, Nina]
Sass, J. (17.01.2007) The numeraire portfolio under transaction costs. Vortrag: PIMS-MITACS Mathematical Finance Seminar, Vancouver/CANADA. [Saß, Jörn]
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Sass, J. (13.12.2007) Trading regions for portfolio optimization under transaction costs. Vortrag: Joint CAF/D-CAF - Thiele Seminar, Aarhus/DENMARK. [Saß, Jörn]
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Huber, Martin (27.04.2007) Simulation of Diffraction in periodic Media with a coupled Finite Element and Plane Wave Approach. Vortrag: Numerical Analysis Day 2007, Vienna/AUSTRIA. [Huber, Martin]
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Ramlau, Ronny (26.06.2007) Blind Deconvolution – Ill-posedness and regularization aspects. Vortrag: Applied Inverse Problems Conference, Vancouver/CANADA. [Ramlau, Ronny]
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Ramlau, Ronny (12.07.2007) Nonlinear Regularization Methods for the Solution of Linear Ill – Posed Problems. Vortrag: FWF-Hearing, Wien/AUSTRIA. [Ramlau, Ronny]
Ramlau, Ronny (17.07.2007) Simultaneous Reconstruction and Segmentation for Tomography Data. Vortrag: ICIAM 2007, Zürich/SWITZERLAND. [Ramlau, Ronny]
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Winterhof, A. (30.08.2007) Pseudorandom numbers and number theory. Vortrag: Ecole d'Ete de Calcul Formel et Theorie des Nombres, Monastir/TUNISIA. [Winterhof, Arne]
Winterhof, A. (10.07.2007) On the k-error linear complexity over Fp of generalized Sidelnikov sequences. Vortrag: Finite Fields and Applications/AUSTRALIA. [Winterhof, Arne]
Winterhof, A. (15.10.2007) Zahlentheorie und Pseudozufallszahlen. Vortrag: Berufungsvortrag (Uni Hildesheim)/GERMANY. [Winterhof, Arne]
Winterhof, A. (20.12.2007) On the structure of inversive pseudorandom number generators. Vortrag: AAECC17/INDIA. [Winterhof, Arne]
Winterhof, Dr. (17.01.2007) Stream Ciphers and Number Theory. Vortrag: Mathematisches Kolloquium (TU Graz)/AUSTRIA. [Winterhof, Arne]
Albrecher, Hansjörg (29.01.2007) Ruin theory in the presence of dividend and tax payments. Vortrag: Versicherungsmathematisches Kolloquium, Cologne/GERMANY. [Albrecher, Hansjörg]
Albrecher, Hansjörg (05.03.2007) Optimale Dividenden- und Besteuerungs-Strategien in der kollektiven Risikotheorie. Vortrag: University of Trier (University of Trier), Trier/GERMANY. [Albrecher, Hansjörg]
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Albrecher, Hansjörg (12.04.2007) Efficient Valuation of Securitization Products. Vortrag: Workshop on Integrated Risk Management, Tilburg/NETHERLANDS. [Albrecher, Hansjörg]
Albrecher, Hansjörg (25.04.2007) A Generic Levy Model for Pricing Synthetic Collateralized Debt

Obligations. Vortrag: IQPC Conference on Correlation Trading, London/UNITED KINGDOM. [Albrecher, Hansjörg]
Albrecher, Hansjörg (21.06.2007) Stochastische Modelle für Versicherungsrisiken. Vortrag: Department of Mathematics, University of Innsbruck, Innsbruck/AUSTRIA. [Albrecher, Hansjörg]
Albrecher, Hansjörg (08.07.2007) Dependence in Collective Risk Theory. Vortrag: 11th Congress on Insurance: Mathematics & Economics, Piraeus/GREECE. [Albrecher, Hansjörg]
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Albrecher, Hansjörg (21.09.2007) Abhängige Risiken und Ruintheorie . Vortrag: Workshop of the German Academy of Actuaries, Günzburg/AUSTRIA. [Albrecher, Hansjörg]
Albrecher, Hansjörg (19.11.2007) Approximationen fuer Gesamtschadenverteilungen und Ruinwahrscheinlichkeiten im subexponentiellen Fall. Vortrag: Autumn Conference of the German Association of Actuaries, München/GERMANY. [Albrecher, Hansjörg]
Albrecher, Hansjörg (26.11.2007) Dividend and Tax Payments in Risk Theory. Vortrag: 37e Journee de seminaires actuariels, Lausanne/SWITZERLAND. [Albrecher, Hansjörg]
Albrecher, Hansjörg (10.12.2007) Tax Payments in Risk Theory. Vortrag: Int. Workshop on Multivariate Risk Management, Eindhoven/NETHERLANDS. [Albrecher, Hansjörg]
Griesse, Roland (15.02.2007) Control Issues in Magnetohydrodynamics. Vortrag: Miniworkshop "Control of Free Boundaries", Oberwolfach, Mathematisches Forschungsinstitut Oberwolfach/GERMANY. [Griesse, Roland]
Griesse, Roland (18.07.2007) Mathematical Methods in MHD Flow Control. Vortrag: 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007, Zurich/SWITZERLAND. [Griesse, Roland]
Griesse, Roland (19.07.2007) KKT Systems Arising in Optimal Control of Magnetohydrodynamics. Vortrag: 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007, Zurich/SWITZERLAND. [Griesse, Roland]
Griesse, Roland (25.07.2007) Update Strategies for Perturbed Nonsmooth Equations. Vortrag: 23rd IFIP TC 7 Conference on System Modelling and Optimization, Krakow/POLAND. [Griesse, Roland]
Griesse, Roland (14.09.2007) An SQP Method for Semilinear Optimal Control Problems with Mixed Constraints. Vortrag: ENUMATH 2007, Graz/AUSTRIA. [Griesse, Roland]
Griesse, Roland (18.09.2007) Stability and Sensitivity Analysis in PDE-Constrained Optimization. Vortrag: 13th Czech-French-German Conference on Optimization, Heidelberg/GERMANY. [Griesse, Roland]
Engl, Heinz W. (19.04.2007) Mathematical Modelling and Numerical Simulation: From Iron and Steel Making via Inverse Problems in Finance. Vortrag: Kick off meeting for a Math Alliance, Kaiserslautern/GERMANY. [Engl, Heinz]
Engl, Heinz W. (03.05.2007) Industrial Mathematics in Linz . Vortrag: Treffen WKO, AVL, Linz/AUSTRIA. [Engl, Heinz]
Engl, Heinz W. (18.05.2007) Mathematical Modelling and Numerical Simulation: From Iron and Steel Making via Inverse Problems to Finance . Vortrag: Habilitation Hend Benameur, Tunis/TUNISIA. [Engl, Heinz]
Engl, Heinz W. (16.07.2007) Identification of the local speed function in a Levy model for option pricing. Vortrag: ICIAM 2007, Zürich/SWITZERLAND. [Engl, Heinz]
Engl, Heinz W. (06.12.2007) Identification and Reverse Engineering of Biological Systems: What Mathematics Can Contribute. Vortrag: EUFEPS Conference on Optimising Drug Discovery and Development together with European Biosimulation Network of Excellence (BioSim), Basel/SWITZERLAND. [Engl, Heinz]
Griesse, Roland (08.03.2007) Optimal Boundary Control of Phase Transitions in a Crystal Growth

Process. Vortrag: Workshop on "Optimization Methods, Approximation and Adaptivity in PDE-Constrained Optimization", Linz/AUSTRIA. [Griesse, Roland]
Griesse, Roland (05.01.2007) Analytical and Numerical Treatment of Optimal Control Problems in Magnetohydrodynamics. Vortrag: Colloquium TU Dresden, Dresden/GERMANY. [Griesse, Roland]
Griesse, Roland (12.01.2007) From Finite-Dimensional Optimization to Optimal Control. Vortrag: Colloquium RWTH Aachen, Aachen/GERMANY. [Griesse, Roland]
Griesse, Roland (18.01.2007) Numerical Methods in PDE-Constrained Optimization. Vortrag: Colloquium TU Chemnitz, Chemnitz/GERMANY. [Griesse, Roland]
Griesse, Roland (09.02.2007) Numerical Methods for Large-Scale Optimal Control Problems. Vortrag: Colloquium University of Basel, Basel/SWITZERLAND. [Griesse, Roland]
Griesse, Roland (14.03.2007) Optimal Control Challenges in Magnetohydrodynamics. Vortrag: Colloquium University of Edinburgh, Edinburgh/UNITED KINGDOM. [Griesse, Roland]
Griesse, Roland (20.04.2007) Optimal Control Challenges in Magnetohydrodynamics. Vortrag: Workshop on "Optimization and Differential Equations", Aguascalientes/MEXICO. [Griesse, Roland]
Griesse, Roland (23.05.2007) Multi-Field Problems in Magnetohydrodynamics and their Optimal Control. Vortrag: Colloquium TU Chemnitz, Chemnitz/GERMANY. [Griesse, Roland]
Griesse, Roland (12.06.2007) Stability and Sensitivity for Optimization Problems with Partial Differential Equations. Vortrag: Colloquium TU Kaiserslautern, Kaiserslautern/GERMANY. [Griesse, Roland]
Griesse, Roland (15.06.2007) The SQP Method for Optimal Control Problems with Mixedl Control-State Constraints. Vortrag: Colloquium University of Trier, Trier/GERMANY. [Griesse, Roland]
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Griesse, Roland (20.09.2007) Optimal Control for MHD Flows. Vortrag: Colloquium SFB 609, Schmochtitz/GERMANY. [Griesse, Roland]
Benedix, Olaf (24.07.2007) A posteriori error estimates for elliptic optimal control problems with inequality constraints. Vortrag: 23rd IFIP TC 7 Conference on System Modelling and Optimization, Krakow/POLAND. [Benedix, Olaf]
Benedix, Olaf (06.11.2007) A-posteriori-Fehlerschätzung für semilineare Optimalsteuerprobleme mit Zustandsbeschränkungen. Vortrag: Kolloquium Wissenschaftliches Rechnen, UniBW München, Neubiberg/GERMANY. [Benedix, Olaf]
Elbau, Dr. Peter (22.11.2007) Non-convex variational methods. Vortrag: BioImaging II/PDE methods, Linz/AUSTRIA. [Elbau, Peter]
Metla, Nataliya (27.03.2007) Convergence of SQP method for nonlinear elliptic problems with mixed constraints. Vortrag: Jahrestagung der Deutschen Mathematiker-Vereinigung, Berlin/GERMANY . [Metla, Nataliya]
Rösch, Arnd; Cherednichenko, Svetlana; Metla, Nataliya (29.03.2007) Approximation and regularization of optimization problems goverment by partial differential equations. Vortrag: RICAM Scientific Board Meeting, Linz/AUSTRIA . [Metla, Nataliya]
Gebauer, Bastian (20.11.2007) Localized potentials in electrical impedance tomography. Vortrag: Workshop on Bioimaging II / PDEs, Linz/AUSTRIA . [Gebauer, Bastian]
He, Lin (19.11.2007) MR Image Reconstruction from Sparse Radial Samples by Using the Iterative Refinement Procedure. Vortrag: Workshop on Bioimaging II / PDEs, Linz/AUSTRIA . [He, Lin]
Kraus, Johannes (09.11.2007) Multilevel methods for non-conforming finite element approximations of elliptic problems with large jumps in the coefficients. Vortrag: Miniworkshop on Multiscale Elliptic Solvers, Linz/AUSTRIA . [Kraus, Johannes]
Elbau, Dr. Peter (04.05.2007) Non-convex semi-group theory for the mean curvature motion. Vortrag: Journées de Metz 2007, PDE and variational methods in image analysis, Metz/FRANCE. [Elbau, Peter]

Pereverzyev Jr., Sergiy (05.10.2007) Optimal Control and Inverse Problems in Radiative Heat Transfer. Vortrag: Annual Meeting 2007 of the DFG-SPP 1253 "Optimization with Partial Differential Equations", Bad Honnef/GERMANY.
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Tomar, S.K. (08.06.2007) A multilevel method for discontinuous Galerkin approximation of three-dimensional anisotropic elliptic problems. Vortrag: 6th International Conference on Large-Scale Scientific Computations, Sozopol/BULGARIA . [Kraus, Johannes; Tomar, Satyendra]
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Kraus, J.K. (08.06.2007) Multilevel Preconditioning of Rotated Trilinear Non-Conforming Finite Element Problems. Vortrag: 6th International Conference on "Large-Scale Scientific Computations", Sozopol/BULGARIA . [Kraus, Johannes]
Beck, T. (22.05.2007) Three Problems in the Context of Formal Desingularization. Vortrag: Workshop on Resolution of Algebraic Varieties, Nove Hrady/CZECH REPUBLIC. [Beck, Tobias]
Fornasier, Massimo (14.12.2007) Mathematical tools in signal processing and sparse optimization. Vortrag: Seminar, Co. ESTECO S.r.l. www.esteco.com, Area Science Park, Trieste, Italy,/ITALY. [Fornasier, Massimo]
Fornasier, Massimo (15.12.2007) Matematica e Arte. Vortrag: Public lecture, Istituto Comprensivo di Correzzola, Comune di Candiana/ITALY. [Fornasier, Massimo]
Rosenkranz, M. (19.11.2007) Noncommutative Polynomials for Boundary Problems. Vortrag: Theorema Seminar, Hagenberg/AUSTRIA. [Rosenkranz, Markus]
Gebauer, Bastian (08.01.2007) Detecting Interfaces in a Parabolic-Elliptic Problem. Vortrag: AMS-MAA Joint Mathematics Meeting, New Orleans, USA, 05.01.07 - 08.01.07, New Orleans/UNITED STATES. [Gebauer, Bastian]
Gebauer, Bastian (09.03.2007) Sampling methods for low-frequency electromagnetic imaging. Vortrag: Inverse Problems in Wave Scattering, Oberwolfach, Germany, 04.03.07 - 10.03.07., Oberwolfach/GERMANY. [Gebauer, Bastian]
Gebauer, Bastian (28.06.2007) Electric potentials with localized divergence properties. Vortrag: Conference on Applied Inverse Problems 2007, Vancouver, Canada, 25.06.07 - 29.06.07., Vancouver/CANADA. [Gebauer, Bastian]
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Gebauer, Bastian (23.11.2007) Localized potentials in electrical impedance tomography. Vortrag: Rhein-Main Arbeitskreis Mathematics of Computation, Mainz, Germany, 23.11.07, Mainz/GERMANY. [Gebauer, Bastian]
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FWF: P18392-N18 - Mathematical Models for Insurance Risk: Exact Solutions and - FWF: P18392-N18

Publikationen:

H. Albrecher, J. Hartinger, S. Thonhauser (2007) Exact solutions for dividend strategies of threshold and linear barrier type in a Sparre Andersen model. Astin Bulletin. [Albrecher, H. (HauptautorIn); Hartinger, J. (KoautorIn); Thonhauser, S. (KoautorIn)]
H. Albrecher, S. Thonauser (2007) Discussion of ``On the Merger of Two Companies". [Albrecher, H. (HauptautorIn); Thonhauser, S. (HauptautorIn)]
H. Albrecher, D. Kortschak Asymptotic results for the sum of dependent non-identically distributed random variables . [Albrecher, H. (HauptautorIn); Kortschak, D. (HauptautorIn)]
H. Albrecher, S. Thonhauser (24.09.2007) Optimal dividend strategies for a risk process under force of interest. Bericht-Nr. 20-2007; Johann Radon Institute for Computational and Applied Mathematics:. [Albrecher, H. (HauptautorIn); Thonhauser, S. (HauptautorIn)]
(2007) Dividend maximization under consideration of the time value of ruin. [Albrecher, H. (HauptautorIn); Thonhauser, S. (HauptautorIn)]

Vorträge/Posterpräsentationen:

Kortschak, Dominik (23.07.2007) Asymptotic results for the sum of dependent non-identically distributed random variables. Posterpräsentation: 5th Converence on Extreme Value Analysis, Bern/SWITZERLAND. [Kortschak, Dominik]
Thonhauser, Stefan (18.09.2007) Optimal Dividend Strategies for a Risk Process Under Force of Interest. Vortrag: Workshop and Mid-Term Conference on Advanced Mathematical Methods for Finance, September, 17th-22nd, 2007/AUSTRIA. [Thonhauser, Stefan]
Thonhauser, Stefan (02.03.2007) Dividend maximization under consideration of the time value of ruin. Vortrag: Seminar za verjetnost in statistiko at University of Ljubljana/SLOVENIA. [Thonhauser, Stefan]
Thonhauser, Stefan (11.10.2007) Optimal dividend strategies for a risk process under force of interest. Vortrag: SOR/QPA Seminar/NETHERLANDS. [Thonhauser, Stefan]
Thonhauser, Stefan (28.03.2007) Dividend maximization under consideration of the time value of ruin. Vortrag: Third Brazilian Conference on Statistical Modelling in Insurance and Finance, Maresias, Brazil/BRAZIL. [Thonhauser, Stefan]
Thonhauser, Stefan (13.04.2007) Dividend maximization under consideration of the time value of ruin. Vortrag: Workshop on Mathematical Control Theory and Finance, Lisbon, Portugal/PORTUGAL. [Thonhauser, Stefan]
Thonhauser, Stefan (12.07.2007) Optimal dividend strategies for a risk process under force of interest. Vortrag: 11th International Congress on Insurance: Mathematics and Economics/GREECE. [Thonhauser, Stefan]

FWF: P18971-N12 - Finite elements for optimal control with singular phenomena - P18971-N12

Vorträge/Posterpräsentationen:

Benedix, Olaf (04.10.2007) Error estimation for semilinear elliptic optimal control problems with state constraints. Vortrag: Annual Meeting 2007 of the DFG-SPP 1253 "Optimization with Partial Differential Equations", Bad Honnef/GERMANY. [Benedix, Olaf]

FWF: P19004-N18 - Pseudorandom sequences - P19004-N18
Beginn: 01.07.2006, geplanter Abschluss: 30.06.2009
Publikationen:

(2007) An inverse of the Faà di Bruno formula. (7). [Pirsic, G. (AlleinautorIn)]
H. Niederreiter, A. Winterhof (2007) Exponential sums for nonlinear recurring sequences. Finite Fields and Their Applications, S. to appear. [Winterhof, A. (HauptautorIn)]
H. Aly, W. Meidl, A. Winterhof (2007) On the k-error linear complexity of cyclotomic sequences. Journal of Mathematical Cryptography, Bd. 1 (3). [Winterhof, A. (HauptautorIn)]
I. Shparlinski, A. Winterhof (2007) Quantum period reconstruction of noisy sequences. Information Processing Letters, Bd. 103 (6), S. 283-296. [Winterhof, A. (HauptautorIn)]
J. Gutierrez, A. Winterhof Exponential sums of nonlinear congruential pseudorandom number generators with Redei functions. Finite Fields and Their Applications, S. to appear. [Winterhof, A. (HauptautorIn)]
S. Balasuriya, I. Shparlinski, A. Winterhof An average bound for character sums with some counter-dependent recurrence sequences. Rocky Mountain Journal, S. to appear. [Winterhof, A. (HauptautorIn)]
(2008) On the distribution of counter-dependent nonlinear congruential pseudorandom number generators in residue rings. International Journal of Number Theory, Bd. to appear. [Gomez, D. (HauptautorIn)]
Brandstätter, Nina (2007) Pseudorandom Number Generators and Character Sums. Doktorarbeit, Johannes Kepler Universität. [Brandstätter, N. (AlleinautorIn)]
Brandstätter, Nina; Winterhof, Arne (16.04.2007) k-Error Linear Complexity of Generalisations of Sidelnikov Sequences. [Brandstätter, N. (HauptautorIn); Winterhof, A. (HauptautorIn)]
D. Gomez, A. Winterhof Character sums of nonlinear recurrence sequences with Dickson polynomials., Finite Fields and Applications; Melbourne, S. to appear. [Gomez, D. (HauptautorIn); Winterhof, A. (HauptautorIn)]
N. Brandstätter, A. Winterhof Subsequences of Sidelnikov sequences., Finite Fields and Applications; Melbourne, S. to appear. [Brandstätter, N. (HauptautorIn); Winterhof, A. (HauptautorIn)]
H. Niederreiter, A. Winterhof (01.12.2007) On the structure of inversive pseudorandom number generators. In: al., S. Boztas et (Hrsg.), AAECC 17; Bangalore, S. 208-216. [Winterhof, A. (HauptautorIn)]
D. Gomez, J. Gutierrez, A. Ibeas (15.06.2007) An algorithm for finding small roots of multivariate polynomials over the integers., LLL+25; Paris, S. to appear. [Gomez, D. (HauptautorIn)]

FWF: P19029-N18 - Mumford-Shah Models for the Inversion of Tomography Data - P19029-N18
Vorträge/Posterpräsentationen:

Klann, E. (12.09.2007) Regularization by Fractional Methods and Data Smoothing. Vortrag: ENUMATH 2007, Graz/AUSTRIA . [Klann, Esther]
Klann, E. (28.08.2007) Simultaneous Reconstruction and Segmentation of Tomography Data. Vortrag: Adaptive Numerical Methods for Inverse Problems (Zentrum fuer Technomathematik, Universitaet Bremen), Bremen/GERMANY. [Klann, Esther]
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FWF: SFB F1303 - Proving and Solving over the Real - SFB F1303
Publikationen:

Moore, Brian; Schicho, Josef; Gosselin, Clement M. (01.07.2007) Determination of the complete set of statically balanced planar four-bar mechanisms. Bericht-Nr. SFB-Report No. 2007-14;. [Moore, B. (HauptautorIn); Schicho, J. (HauptautorIn)]
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Vorträge/Posterpräsentationen:

Moore, B. (29.05.2007) Static balancing of parallel mechanisms. Posterpräsentation: IMA Annual Program Year Workshop: Non-Linear Computational Geometry, Minneapolis/UNITED STATES. [Moore, Brian]
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FWF: SFB F1308 - Computational Inverse Problems and Applications - SFB F1308

Publikationen:

J.M.J. Huttunen, H.K. Pikkarainen (2007) Discretization error in dynamical inverse problems: one-dimensional model case. Journal of Inverse and Ill-posed Problems, Bd. 15 (4), S. 365-386. [Pikkarainen, H. (HauptautorIn)]
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A. Neubauer, H.K. Pikkarainen (27.11.2007) Convergence results for the Bayesian inversion theory. Bericht-Nr. 2007-29; SFB F013:. [Pikkarainen, H. (HauptautorIn)]

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Pikkarainen, H.K. (18.07.2007) Convergence rates for the Bayesian approach to linear inverse problems. Vortrag: 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007, Zurich/SWITZERLAND. [Pikkarainen, Hanna Katriina]
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FWF: SFB F1315 - Numerical and Symbolic Methods for Implicity Defined Spline Surfaces - SFB F1315

Publikationen:

Kapl, Mario; Juettler, Bert (15.06.2007) Weighted Biorthogonal Spline Wavelets. Bericht-Nr. SFB Report 2007-13;. [Kapl, M. (HauptautorIn)]
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Texas): Nashboro Press. [Kapl, M. (HauptautorIn)]

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FWF: SFB F1322 - Computer Algebra for Pure and Applied Functional Analysis - SFB F1322

Publikationen:

Regensburger, Georg (2007) Parametrizing compactly supported orthonormal wavelets by discrete moments., Bd. 18 (6), S. 583-601 . [Regensburger, G. (AlleinautorIn)]
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Regensburger, Georg (2007) Applications of filter coefficients and wavelets parametrized by moments. In: Park, Hyungju; Regensburger, Georg (Hrsg.); Berlin: Walter de Gruyter & Co., S. 191-214. [Regensburger, G. (AlleinautorIn)]
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Park, Hyungju; Regensburger, Georg (Hrsg.) (2007) Gröbner Bases in Control Theory and Signal Processing. In Reihe: Radon Series on Computational and Applied Mathematics; Berlin: Walter de Gruyter & Co (251 Seiten). [Regensburger, G. (HauptautorIn)]
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Vorträge/Posterpräsentationen:

Rosenkranz, M.; Regensburger, G. (13.04.2007) Solving and Factoring Boundary Problems in Differential Algebra. Vortrag: SFB Status Seminar, Strobl/AUSTRIA. [Regensburger, Georg; Rosenkranz, Markus]
Regensburger, G.; Rosenkranz, M. (13.04.2007) Abstract Boundary Problems and Applications. Vortrag: SFB Status Seminar, Strobl/AUSTRIA. [Regensburger, Georg; Rosenkranz, Markus]
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Regensburger, G. (22.05.2007) Generalized Solutions for nonlinear first-order ODEs and Max-plus Interpolation. Vortrag: Workshop Algebraic Geometry, Nové Hrady/CZECH REPUBLIC. [Regensburger, Georg]
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FWF: Y192 - 3D hp-Finite Elements: Fast Solvers and Adaptivity - FWF: Y192
Publikationen:

Schöberl, J.; Melenk, J.M.; Pechstein, C.; Zaglmayr, S. (2008) Additive Schwarz preconditioning for p-Version Triangular and Tetrahedral Finite Elements. IMA Journal on Numerical Analysis. [Zaglmayr, S. (HauptautorIn)]
Schöberl, Joachim; Sinwel, Astrid (15.06.2007) Tangential-Displacement and Normal-Normal-Stress Continuous Mixed Finite Elements for Elasticity. Bericht-Nr. RICAM-Report No. 2007-10; RICAM: Linz. [Sinwel, A. (HauptautorIn)]
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Vorträge/Posterpräsentationen:

Sinwel, Astrid (26.09.2007) Mixed Finite Elements for Linear Elasticity. Posterpräsentation: Chemnitzer FEM Symposium, Chemnitz/GERMANY. [Sinwel, Astrid]
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Sinwel, Astrid (30.10.2007) Mixed Finite Elements for Linear Elasticity. Vortrag: Applied Math Seminar, University of Delaware/UNITED STATES. [Sinwel, Astrid]
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Zaglmayr, S. (27.04.2007) Equilibrated residual a-posteriori error estimators for Poisson and Maxwell's equations. Vortrag: 3rd Numerical Analysis Day (TU Wien), Vienna/AUSTRIA. [Zaglmayr, Sabine]
Zaglmayr, Sabine; Schöberl, Joachim (19.05.2007) High Order Finite Elements for Vector-Valued Function Spaces . Vortrag: HOFEM Herrsching (TU München), Herrsching/GERMANY. [Zaglmayr, Sabine]
Zaglmayr, Sabine; Schöberl, J.; Braess, D. (24.07.2007) Equilibrated residual a-posteriori error estimators for Poisson and Maxwell's equations. Vortrag: USNCCM9, San Francisco, CA/UNITED STATES. [Zaglmayr, Sabine]
Zaglmayr, Sabine; Schöberl, Joachim (30.07.2007) hp-Finite Elements with local exact sequence property: Applied within Robust Preconditioning and the Maxwell EVP. Vortrag: Lawrance Livermore National Lab , Livermore /UNITED STATES. [Zaglmayr, Sabine]
Zaglmayr, Sabine; Schöberl, J.; , D. Braess (25.09.2007) Equilibrated residua-based a priori error estimators for Poisson and Maxwell's equations. Vortrag: Chemnitz FEM Symposium /GERMANY. [Zaglmayr, Sabine]
Zaglmayr, Sabine (06.10.2007) On High Order Finite Element Methods for Maxwell's Equations. Vortrag: 5th Workshop on Fast Boundary Element Methods in Industrial Applications, Kleinwalsertal/AUSTRIA. [Zaglmayr, Sabine]

MOIF-CT 2006-039438 - SPARSE, Marie-Curie Fellowship - MOIF-CT 2006-039438
Publikationen:

Massimo Fornasier, Holger Rauhut (2007) Iterative thresholding algorithms . Applied and Compuational Harmonic Analysis. [Fornasier, M. (KoautorIn)]
Maria Charina, Costanza Conti, and Massimo fornasier Adaptive frame methods for nonlinear variational problems . Numerische Mathematik. [Fornasier, M. (HauptautorIn)]
Fornasier, Massimo (2007) Domain decomposition methods for linear inverse problems with sparsity constraints. Inverse Problems, Bd. 23, S. 2505–2526 . [Fornasier, M. (AlleinautorIn)]
Ingrid Daubechies, Massimo Fornasier, and Ignace Loris Accelerated projected gradient methods for

linear inverse problems with sparsity constraints . Journal of Fourier Analysis and Applications. [Fornasier, M. (KoautorIn)]
Massimo Fornasier, Riccardo March (2007) Restoration of color images by vector valued BV functions and variational calculus . SIAM Journal on Applied Mathematics, Bd. 68 (2), S. 437–460 . [Fornasier, M. (KoautorIn)]
Massimo Fornasier, Francesca Pitolli (2007) Adaptive itererative thresholding algorithms for magnetoencephalography (MEG) . Journal of Computational and Applied Mathematics . [Fornasier, M. (KoautorIn)]
Massimo Fornasier, Laura Gori (2007) Sampling theorems on bounded domains . Journal of Computational and Applied Mathematics . [Fornasier, M. (KoautorIn)]

WWTF MA 05: Modeling the Dynamics of Cellular Networks Using Inverse Methods

Publikationen:

Christoph Flamm, Lukas Endler, Stefan Müller, Stefanie Widder, Peter Schuster (2007) A minimal and self-consistent in silico cell model based on macromolecular interactions. Phil Trans R Soc Lond B Biol Sci, Bd. 362 (1486), S. 1831-1839 . [Müller, S. (HauptautorIn)]
Lu J, Engl HW, Schuster P (15.06.2007) Inverse bifurcation analysis of a model for the mammalian G1/S regulatory module. In: Hochreiter S, Wagner R (Hrsg.), Lecture Notes in Bioinformatics (Bioinformatics Research and Development); Berlin: Springer , S. 168-184. [Lu, J. (HauptautorIn)]

Vorträge/Posterpräsentationen:

Rainer Machne, James Lu, Stefan Müller, Christoph Flamm (02.10.2007) SBML ODE Solver Library: Extensions for Inverse Analysis. Posterpräsentation: The Eighth International Conference on Systems Biology, Long Beach/UNITED STATES . [Lu, James; Müller, Stefan]
Rainer Machne, Lukas Endler, James Lu, Stefan Müller (02.10.2007) The evolution of the bifurcation phenotype: phylogenetic and dynamical analysis of fungal GATA networks. Posterpräsentation: The Eighth International Conference on Systems Biology, Long Beach/UNITED STATES . [Lu, James; Müller, Stefan]
James Lu, Stefan Müller, Rainer Machne, Christoph Flamm (01.10.2007) Tutorial: Inverse methodologies for systems biology: SOSlib, MathSBML and Matlab extensions. Vortrag: The Eighth International Conference on Systems Biology, Long Beach/UNITED STATES . [Lu, James; Müller, Stefan]
Lu, J (13.11.2007) Inverse analysis for qualitative aspects of gene networks. Vortrag: Workshop on Systems Biology (RICAM), Linz/AUSTRIA . [Lu, James]
Lu, J (05.01.2007) Inverse dynamical analysis: from probing possible dynamical behaviors to inferring mechanisms underlying gene regulation. Vortrag: Dynamics Days 07, Boston/UNITED STATES. [Lu, James]
Lu, J (19.07.2007) Inverse eigenvalue analysis: methodology and application to eukaryotic GATA transcription factor system. Vortrag: International Congress on Industrial and Applied Mathematics /SWITZERLAND . [Lu, James]
Lu, J (18.07.2007) Inverse analysis for qualitative aspects of gene networks. Vortrag: International Congress on Industrial and Applied Mathematics , Zurich/SWITZERLAND . [Lu, James]
Müller, Stefan (09.11.2007) Parameter identification in systems biology: solving inverse problems using regularization. Vortrag: Special Semester on Quantitative Biology analyzed by Mathematical Methods: Workshop on Systems Biology, Linz/AUSTRIA . [Müller, Stefan]

Softwareprodukte:

Titel	Personen	Typ d. Urheberschaft
SBML Inverse Eigenvalue Analyzer	Lu, James	ÖAW-intern gemeinsam mit extern finanzierten Dritten

Mathematical Methods for Image Analysis and Processing in Visual Arts

Vorträge/Posterpräsentationen:

Kuijper, A. (14.09.2007) Images at Multiple Scales. Vortrag: WWTF meeting (WPI), Wien/AUSTRIA. [Kuijper, Arjan]

WWTF CI06 003 Mathematical Methods for Image Analysis and Processing in the Visual Arts

Vorträge/Posterpräsentationen:

Fornasier, Massimo (09.11.2007) Mathematics and art restoration. Vortrag: Seminar, Institut für Konservierung und Restaurierung, Akademie der bildenden KünsteWien/AUSTRIA. [Fornasier, Massimo]

Doktoratskolleg: Computational Mathematics - Numerical Analysis and Symbolic Computatio - DK

Nonlinear scale space approaches to image analysis

Publikationen:

Kuijper, A. (2007) Deriving the Medial Axis with Geometrical Arguments for Planar Shapes. Pattern Recognition Letters, Bd. 28 (15), S. 2011-2018 . [Kuijper, A. (AlleinautorIn)]
A.Kuijper (15.06.2007) Image Processing with Geometrical and Variational PDEs., 31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07 (31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07); Schloss Krumbach: OCG, S. 89--96 . [Kuijper, A. (AlleinautorIn)]
Kuijper, A. (15.06.2007) Image analysis using p-Laplacian and geometrical PDEs., 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007) (6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007)), S. 157 . [Kuijper, A. (AlleinautorIn)]
Havukkala, A. Kuijper and I. (15.06.2007) Computationally Efficient Matching of MicroRNA Shapes using Mutual Symmetry., 9th IASTED International Conference on Signal and Image Processing (SIP 2007, Honolulu, Hawaii, USA, August 20-22, 2007) (9th IASTED International Conference on Signal and Image Processing (SIP 2007, Honolulu, Hawaii, USA, August 20-22, 2007)), S. 477--482 [Kuijper, A. (HauptautorIn)]
A.Kuijper (15.06.2007) p-Laplacian driven image processing., 14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007) (14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007)) In Reihe: Proceedings ICIP - IEEE: IEEE, S. Vol. V, pages 257--260 . [Kuijper, A. (AlleinautorIn)]
Kuijper, A. (15.06.2007) Qualitative and Quantitative Behaviour of Geometrical PDEs in Image Processing., LNCS 4843 (8th Asian Conference on Computer Vision, ACCV 2007 (Tokyo, Japan, Nov. 18-22, 2007)) In Reihe: LNCS: Springer, S. 230--239 . [Kuijper, A. (AlleinautorIn)]

Vorträge/Posterpräsentationen:

Kuijper, A. (18.09.2007) p-Laplacian driven image processing. Posterpräsentation: 14th International Conference on Image Processing, ICIP 2007 (San Antonio, Texas, USA, 16-19 September 2007), San Antonio/UNITED STATES . [Kuijper, Arjan]
Kuijper, A. (19.11.2007) Qualitative and Quantitative Behaviour of Geometrical PDEs in Image Processing. Posterpräsentation: 8th Asian Conference on Computer Vision, ACCV 2007 (Tokyo, Japan, Nov. 18-22, 2007), Tokyo/JAPAN . [Kuijper, Arjan]
A.Kuijper (04.05.2007) Image Processing with Geometrical and Variational PDEs. Posterpräsentation: 31st annual workshop of the Austrian Association for Pattern Recognition (OAGM/AAPR), OEAGM07 (Schloss Krumbach, Austria, May 3-4, 2007),, Krumbach/AUSTRIA . [Kuijper, Arjan]
Havukkala, A. Kuijper and I. (22.08.2007) Computationally Efficient Matching of MicroRNA Shapes using Mutual Symmetry. Vortrag: 9th IASTED International Conference on Signal and Image Processing (SIP 2007, Honolulu, Hawaii, USA, August 20-22, 2007),, honolulu/UNITED STATES . [Kuijper, Arjan]
A.Kuijper (19.07.2007) Image analysis using p-Laplacian and geometrical PDEs. Vortrag: 6th International Congress on Industrial and Applied Mathematics, ICIAM 2007 (Zurich, Switzerland, 16-20 July 2007), , Zurich/SWITZERLAND . [Kuijper, Arjan]
Kuijper, A. (11.06.2007) Inpainting with higher order energies. Vortrag: PDEs and Variational Tools in Image Inpainting, Wien/AUSTRIA. [Kuijper, Arjan]
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colloquium (WPI), Wien/AUSTRIA. [Kuijper, Arjan]
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