Fraunhofer ITWM

CHALMERS
Research Centre
Industrial Mathematics

Annual Report 2003

FCC

Fraunhofer-Chalmers Research Centre for Industrial Mathematics

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Cover

A graphic of the DNA molecule, showing its spiral double helix structure, cf page 20 - 21.

Annual Report 2003

Fraunhofer-Chalmers Research Centre
for Industrial Mathematics, FCC

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Preface

Having started its operations in September 2001, FCC is still a very young organization. We have successfully gone through our first phase by recruiting a staff of seventeen people (five new recruitments in 2003) housed in appropriate premises in Chalmers Science Park and working on projects with a total volume of 2000 kEUR in 2003.

FCC has the ambition to cover a wide range of applications together with our partners Chalmers and the Fraunhofer industrial mathematics institute ITWM. From the beginning in 2001 we have started more than eighty projects, fifty of which have been completed, with companies and organizations of different size and from different branches.

A striking example is the development of methods and algorithms in automatic path planning for robots and rigid bodies. A software platform has been developed in a sequence of projects with industrial clients, where a number of challenging test cases have successfully been solved. A public three-year project on path planning and flexible automatic off-line programming for geometrical measuring equipment has been approved in 2003 with a budget of 400 kEUR.

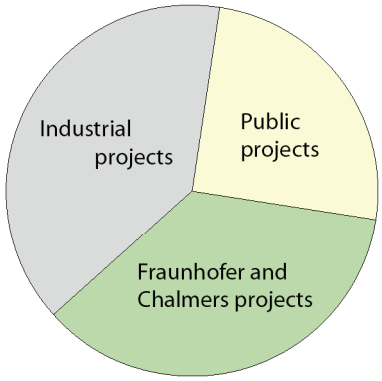
In line with the Fraunhofer model, the profile of the Centre is controlled by its income structure. The result of 2003 is well in line with the business plan of March 2001, scientifically as well as commercially. The total income is 15% above expectations and generates a positive financial net. The project volumes from industry (39%), public financieers (26%) and Fraunhofer and Chalmers (35%) are well in balance.

Before ending this preface I take the opportunity to thank my coworkers at FCC for their enthusiastic commitment to form our new Centre, and express my appreciation of the fruitful collaboration with our friends at Chalmers and Fraunhofer ITWM on a local as well as European scale.

Göteborg in April 2004

Uno Nävert
Director

FCC operates in Chalmers Science Park.



Income structure 2003, total income 2000 kEUR.

Uno Nävert, Director of FCC.

www.fcc.chalmers.se

Profile

Mathematics has become a key technology for industrial innovation since mathematics is behind all work in the virtual world.

The Fraunhofer Society and Chalmers have founded FCC to promote the application of mathematical methods in industry. To do so the Centre undertakes scientific research and marketing financed by the founders and works on projects defined by companies and public institutes on a commercial basis.

FCC is an example of a bottom-up strategy to build the European research space. First we define a small network of closely (daily) co-operating research institutes. To solve concrete problems from companies from all over Europe, we then create optimal teams built out of this network. We do this in the field of mathematics, which is a key technology for industrial innovation, lying behind all work in the virtual world, e g, simulation for prediction, control, optimization, and risk assessment.

FCC works on projects defined by companies and public institutes on a commercial basis.

Entrepreneurial competence

The Swedish Society of Applied Mathematics, STM, is a consortium of big companies with business in Sweden, cf page 5. This consortium is the largest individual industrial client of FCC and represents one third of the total industrial income.

Experiences from Fraunhofer show that small and medium size companies constitute an important market for an industrial mathematics institute. The number of SME projects at FCC steadily increases and now represents eight percent of the total industrial income.

The Centre has served international industrial clients from Denmark, France, Germany, Italy, and Norway.

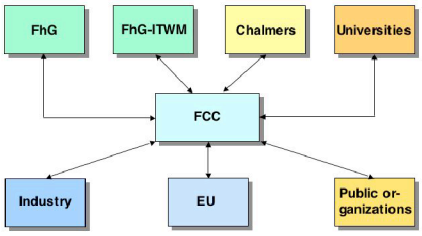
Professional networking

The Centre has a very close relation to its founders Chalmers and Fraunhofer ITWM, cf pages 6 - 9, exchanging staff members, co-operating in projects, by joint participation in European projects, by connecting Swedish clients with ITWM and vice versa, and by stimulating the co-operation between Swedish industry and other Fraunhofer institutes.

In order to fulfil its tasks optimally, the Centre co-operates with competent scientific groups at universities and elsewhere, cf page 14 - 15.

It also promotes research and education in industrial mathematics at institutions outside the Centre, cf pages 8 - 9, 14 - 15, and 19.

FCC in close co-operation with Chalmers and Fraunhofer shall be a leading international partner in industrial mathematics.

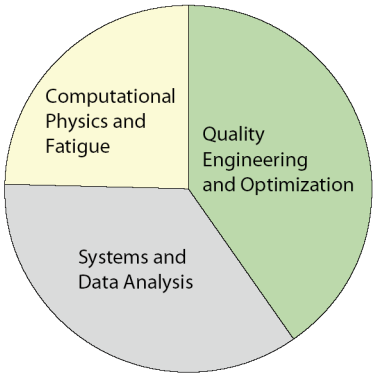


Scientific competence

The Centre undertakes scientific research projects and marketing of scientific results financed by its founders and by public institutes. Respecting the confidentiality of data from customers, the Centre encourages the publication of results. FCC supports efforts to use its research for educational purposes at all levels at Chalmers as well as at other educational institutions in Sweden and Europe. FCC sponsors PhD work, if the subjects are of basic interest for the research in the Centre. FCC keeps contact with the worldwide community of applied mathematicians by active participation in conferences and by inviting guest scientists.

The Centre has organized six research programmes within three technology areas. By the end of 2003 the staff was eighteen full-time equivalents, including one scientist contracted from Fraunhofer ITWM and six scientific advisers from Chalmers, each one working 10% - 20% of full time at FCC.

FCC undertakes scientific research financed by its founders and by public institutes.



Relative turnover 2003

Financial mix

The financial model distinguishes between three income sources: project financing from the founders, industrial project income, and public project income. These three should be in reasonable balance.

According to the business plan of March 2001, the annual turnover of the Centre shall increase from 1700 kEUR in 2001 - 2002 (18 months) to 2000 kEUR in 2004. The outcome has been above expectations. In particular, the industrial income has been higher than expected, cf pages 22 - 23.

After three years FCC shall earn approximately 40% from its founders, 40% industrial income, and 20% public income.

Acknowledgements

The Centre is a Swedish foundation established by Chalmers and Fraunhofer-Gesellschaft. The decision has been based on a business plan prepared by the Swedish Institute for Applied Mathematics (ITM) and Fraunhofer-Institut für Techno- und Wirtschaftsmathematik (ITWM).

The Swedish Association for Applied Mathematics (STM) and the former Swedish National Board for Technical and Industrial Development (NUTEK) have supported FCC taking over ITM operations.

The Swedish Foundation for Strategic Research (SSF) has played an essential role by announcing support of one million euros for a public project where a future scientific leader is recruited to establish a research team at the Centre.

Clients and Partners

FCC has successfully co-operated with enterprises of different sizes and from many branches. In the following, those clients and project partners are listed who have accepted to be cited.

- ABB
- ABB Robotics
- ABB Power Technologies
- Aerotech Telub
- AstraZeneca R&D Mölndal
- AstraZeneca R&D Södertälje
- Atlas Copco Rock Drills
- Bombardier Transportation
- Consorzio Politechnico Innovazione (I)
- Elforsk
- Elmo Leather
- Ericsson
- Ericsson Microwave Systems
- Faurecia Exhaust Systems
- FOI
- Fortum Power and Heat OY
- Front Capital Systems
- InNetics
- Innovativ Vision
- IVF Industriforskning
- Jernkontoret
- NMCT
- Novo Nordisk (DK)
- Optimization Partner Stockholm
- PlanIt
- PSA Peugeot Citroën (F)
- Saab
- Saab Automobile
- Saab Ericsson Space
- Safe Technology
- Saint-Gobain Sekurit Scandinavia
- Sandvik Steel
- Scania
- Simula Research Laboratory AS (N)
- SKF
- STM Forskningsservice
- Sveriges Provnings- och Forskningsinstitut SP
- StoraEnso Corporate Research
- Sveriges Försäkringsförbund
- Sydkraft
- Uddcomb
- Universitetssjukhuset MAS
- Volvo Aero Corporation
- Volvo Car Corporation
- Volvo Trucks

- Chalmers tekniska högskola
- Chalmers Finite Element Centre
- Chalmers Industriteknik
- Chalmers Matematik
- Chalmers Wingquist Laboratory
- Fraunhofer ITWM (D)
- Fraunhofer IGD (D) / EU ViSiCADE
- ITM
- Kungliga Tekniska Högskolan /PSCI
- Linköpings Universitet / Beräkningsbiologi
- Linköpings Universitet / Reglerteknik
- Lunds Universitet / Matematisk statistik

STM

The Swedish Society for Applied Mathematics (STM) has signed a letter of intent to finance projects at FCC with 700 kEUR in the period 2001 - 2004.

Members and shares 2003:

Engineering and transport	
Volvo	5
SKF	5
ABB	3
Saab	3
Sveriges Provnings- och Forskningsinstitut SP	1
Pharmaceuticals	
AstraZeneca R&D Mölndal	5
AstraZeneca R&D Södertälje	2
Telecommunications	
SaabTech Systems	0,5
Ericsson Microwave Systems	1
Ericsson Radio Systems	0,5
Ericsson	1
TeliaSonera Sverige	1
Energy	
Elforsk	5
Insurance and finance	
Sveriges Försäkringsförbund	5
Front Capital Systems	0,5
Wood, pulp, paper	
StoraEnso Corporate Research	1
Authorities	
Statistiska Centralbyrån SCB	1
	40,5

www.itm.se/stm.html

Fraunhofer-Gesellschaft

Professor Helmut Neunzert, ITWM, Vice Chairman of FCC.

The Fraunhofer-Gesellschaft is Germany's leading organization of institutes of applied research. It undertakes contract research on behalf of industry, the service sector, and government.

The FhG works within the framework of the European Union's technology programs, striving to improve the competitiveness of European industry through the enhancement of technical systems and processes. Commissioned and funded by the Federal and State governments, the FhG undertakes strategical research projects which contribute to the development of innovations in key technologies and spheres of major public concern, such as energy, transport and the environment.

The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. It currently maintains 58 research institutes throughout Germany. A staff of 12700, the majority of whom are scientists and engineers, generate the annual research budget of more than one billion euros. Work focuses on specific tasks across a wide spectrum of research fields. Where systematic solutions are required, several institutes collaborate on an interdisciplinary basis.

The Institut für Techno- und Wirtschaftsmathematik (ITWM) in Kaiserslautern became a Fraunhofer institute on January 1, 2001, after an exceptional development. The budget increased from 1500 kEUR in 1996 to 5000 kEUR in 2000 and the staff increased from 34 to 81 in the same period. Its Director is Professor Dieter Prätzel-Wolters.

The ITWM is organized into seven units, which also reflect key competence fields: Departments in Transport Processes, Flow in Complex Structures, Models and Algorithms in Image Processing, Adaptive Systems, Optimization, Financial Mathematics, and the Competence Centre High Performance Computing and Visualization.

Professor Helmut Neunzert is responsible for international affairs at ITWM. FCC originates from his vision of a European institution operating in the Fraunhofer spirit.

Co-operation

A key element in the operation of FCC is its close co-operation with ITWM. In 2003 this project volume was 150 kEUR.

Finance and insurance

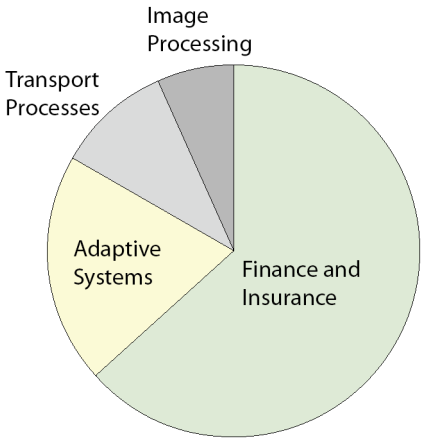
A special effort has been done in this area which is the most expansive one at ITWM. Dr Gerald Kroisandt from ITWM has spent the full year at FCC, mainly working with the Swedish insurance industry.

www. fraunhofer.de
www.itwm.fraunhofer.de

On both European and national levels, new rules are under way to account for the solvency of banks (Basel 2) and insurance companies (Solvence 2). In a project with the Swedish Insurance Federation, FCC has analyzed different risk measures and interest rate models for the development of the Swedish rules.

For risk measures, there are four main assumptions that should be fulfilled. The aim was to investigate the possibility to use standard premium calculation principles as a risk measure. The agreement between the premium principle and the risk measure should guarantee the transparence of the calculations for the supervising agency. The interesting fact is that assumptions imposed on premium principles can be identified with assumptions on risk measures.

By the end of the year, a project on simulation models for asset-liability management of pension funds was defined together with AP2, the Second Swedish National Pension Fund, cf page 19.



ITWM income from FCC projects in 2003, in total 150 kEUR.

Transport processes

The main competence of this ITWM department is the mathematical modelling of complex industrial problems and the development of efficient algorithms for their numerical solution (simulation). In connection with an FCC project with a Swedish industrial partner, ITWM has been contracted to study modelling of thin film layers, their numerical treatment with respect to theoretical and computational aspects, and methods used by some commercial software.

Adaptive systems

The main competence of this ITWM department is in the fields of system and control theory, stochastics and statistics, data mining, and asymptotic homogenization. In connection with an FCC project with a Swedish industrial partner, ITWM has assisted in developing a flexible collision detection library adapted to robotics applications. Similarly, ITWM has assisted in developing a method that utilizes interaction variable data as boundary conditions for simulations of sub-systems as parts of large systems.

Image processing

The main focus of this ITWM department is the development of complex algorithms for image and signal processing, and their implementation into efficient software within complete systems. An FCC - ITWM project with a Swedish industrial partner has adressed surface inspection, in particular quality classification and defect detection.

Chalmers

Professor Peter Jagers, Chalmers, Chairman of FCC.

The Chalmers University of Technology (Chalmers tekniska högskola) was founded in 1829. It is a non-profit, non-governmental university. With its more than 8000 students for engineering and architecture degrees, and more than 1100 PhD students it is one of Sweden's two leading technology universities.

Most of Chalmers' resources come from contracts with the state of Sweden (65%), but Chalmers also has strong support from non-governmental research organizations (22%) and industry (13%). The annual (2003) turnover is 240 million euros. More than two thirds of the budget are alotted to research and to graduate studies. With its staff of 2500 full time equivalents, including 158 full professors, the University has strong and well-known departments in most fields of science and engineering.

Chalmers has made special efforts to integrate mathematics into a broader scientific and technological perspective. Strong activities in stochastics and numerical and modelling mathematics have emerged. Thus, besides activities in the various mathematical fields, Chalmers Applied Mathematics comprises three more specialized centres.

Professor Peter Jagers was the President of the Chalmers Faculty Senate 1993 - 2002. He brought up the idea of engaging Chalmers in a joint venture, when the Fraunhofer Society started to look for Swedish partners. He also represented Chalmers in the subsequent negotiations.

Co-operation

A key element in the operation of FCC is its close co-operation with Chalmers.

This co-operation is mainly organized through six scientific advisers. Each adviser typically spends between 10 and 20 percent of full time at the Centre. Four advisers are senior scientists at the School of Mathematical Sciences and two advisers are senior scientists at the School of Mechanical Engineering.

In several cases FCC staff members act as co-advisers for PhD students at Chalmers. FCC also finances PhD projects at Chalmers.

The co-operation has been particularly strong in four areas: Computational Physics, Fatigue Life, Optimization, and Quality Engineering. In different settings, Chalmers and FCC have worked together in externally financed projects, as described below by the scientific advisers.

www.chalmers.se
www.math.chalmers.se

Computational Physics

FCC interacts with activities in the Chalmers Finite Element Centre Phi, a centre focusing on the interdisciplinary development and application of finite element based computational technology. Examples of joint activities include the EU-project ViSiCADE, co-ordinated by Fraunhofer IGD, and a PhD project carried out by Leonid Gershuni on finite element methods for thin film flow, cf pages 10 - 11.

Statistical Fatigue of Materials

The establishment of FCC has made it possible for the fatigue group to host competence for solving particular industrial problems as well as for doing purely academic work.

The strategy has been to consider the fatigue group as one unit jointly supported by Chalmers and FCC. In that way, problems from industry are imported into the academic work and research results are exported to industry. This two-way communication has proved fruitful for the students at Chalmers, as well as for the industrial partners, cf pages 12 - 13.

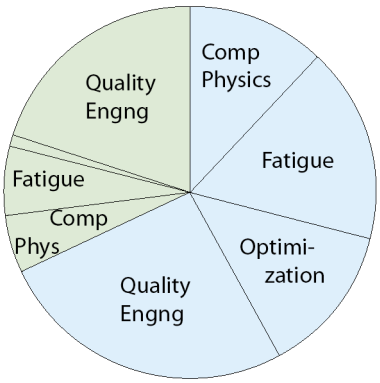
Optimization

Dr Ann-Brith Strömberg at FCC is the co-adviser of two PhD students in optimization at Chalmers. She also shares the responsibility for the course on optimization under uncertainty, given at the Department of Mathematics. The course incorporates a current project at FCC on the topic of optimization under uncertainty, thus bringing knowledge of the state-of-the-art use of applied mathematics in practice to the students, cf pages 14 - 15.

Quality Engineering

Wingquist Laboratory was started in October 2001 as an important part of a major renewal and reorganization of the School of Mechanical and Vehicular Engineering at Chalmers. The motivation was to increase the collaboration with Swedish industry and to concentrate research in strategic areas.

The laboratory conducts interdisciplinary research within the field of virtual product realization, focused on modelling, simulation, evaluation and verification of product and production concepts. Research efforts are carried out in three closely related areas; 1) product- and production system modelling, 2) robust design and variation simulation, and 3) flexible production and automation systems, cf pages 16 - 17.



Income 2003 from projects where Chalmers (blue) and FCC (green) work together, in total 416 kEUR (Chalmers) and 193 kEUR (FCC).

"Together, FCC and Wingquist Laboratory possess a unique set of competence that enables industrial projects with extraordinary requirements in the field of simulation and analysis to be carried out successfully."

Professor Rikard Söderberg,
Director Wingquist Laboratory,
Scientific adviser FCC

Computational Physics

General

The FCC reasearch in Computational Physics focuses on computer simulation of physical phenomena, including fluids, solids, and electromagnetics.

Geometry and Mesh Generation

The starting point of many industrial computations is the creation of a mesh with desired properties and quality. Often this task is difficult and time consuming due to bad quality of CAD data and lack of robust 3D mesh generators. Furthermore, special meshes, for instance boundary fitted or hybrid meshes are often desired in applications.

Adaptive Methods

Computer simulations enable rapid design and optimization of products. Design optimization may, for instance, involve choice of suitable materials, geometrical shape, and even topology. Typically these problems require rapid solvers and efficient optimization algorithms.

Modern finite element techniques for solution of differential equations are based on a multi-resolution approximation of the solution, where the local resolution is determined in an adaptive fashion. To obtain desired accuracy we employ techniques for estimation of the errors in the computations. Such computational error estimation techniques have developed rapidly during the last decade and it is now possible to control the global error measured in a norm or the error in particular quantities of interest. An illustrating example of such quantities of interest is the lift and drag coefficients of an airfoil.

Inverse Problems and Optimization

Inverse problems typically involves determination of quantities or objects from measured data, for instance detection of defects in a material using ultrasound measurements. Inverse problems are closely related to shape/topology and design optimization problems in engineering where we seek to determine an optimal design (in a suitable sense).

Multiscale Computations

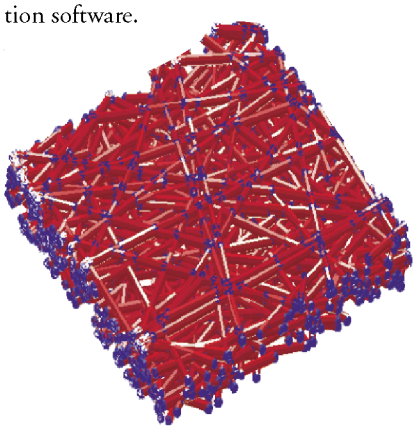
Often physical problems exhibit multiscale behavior. For instance, a composite material may be described by fibers in a matrix on the microscale and perhaps linear elasticity on the macroscale. Multiscale computational methods are techniques used to handle such problems. Typically, these techniques involve solution at the microscale and computation of macroscopic quantities or the effect of the microscale on the macroscale.

Some projects

Computational Modeling of Paper

Based on, for instance, pictures of microstructure of a material a mathematical model of the microstructure can be constructed and simulations of its properties can be done. Examples of simulations include fluid flow in a filter or the mechanical response of a small piece of a composite or foam material under load. Based on these computations estimates of parameters in macroscopic equations may be obtained. A natural next step is virtual design and optimization of materials where we instead seek to construct microstructures which give desired macroscopic properties.

In a project supported by STM Research and StoraEnso we have developed such computer models of paper. The models focus on simulation of the mechanical properties of paper and are implemented in a demonstration software.



A network model of fibres for finite element simulation of the properties of paper.

In a second step we have developed a more general framework for efficient multiple simulations of parameterized models. Each simulation includes some tens or hundreds of primitive (sub) simulations. In the paper model case, each primitive represents one sample generated from the seed to a pseudo random generator to account for the stochastic model of fibre lengths and orientations.

Our framework makes it possible to get fast response times by using pre-computed simulation results. The simulation results could be examined with a GUI allowing interactive exploration. The model is compared with the measured properties for three different paper samples.

Finite Element Software

In a project with Simula Research Laboratory AS Norway, software has been implemented in the Diffpack software library. Diffpack is marketed by inuTech GmbH Germany. The topic of FCC's work has been higher order finite elements and a discontinuous Galerkin finite element method. By the used technique it is possible to let the element order vary from element to element in the computational mesh. The mesh is built of triangular and tetrahedral elements in two and three space dimensions, respectively. Combining the new methods with the in Diffpack previously developed mesh refinement toolbox has made it possible to develop an hp-adaptive finite element method, where p-refinement refers to increasing the element order, and h-refinement to splitting elements. A multigrid method has been developed which solves the system of equations resulting from the discretization of the hp-mesh. The multigrid method has near optimal complexity, meaning that also discretizations with a large number of degrees of freedom could be solved.

ViSiCADE

In the EU project ViSiCADE in the IST program, IST2000-28123, FCC takes part as a subcontractor to Chalmers. The objective of the ViSiCADE project is to develop an intuitive simulation framework based on virtual reality.

The role of FCC is to develop fast finite element solvers enabling the user of the developed system to make interactive simulation. A technique for making interactive simulations is submodeling where the accuracy of the solution in a subdomain is enhanced by solving a local problem on the subdomain with data obtained from a coarse solution. Further the geometry or material properties in the subdomain may be changed, providing the possibility to study the effect of design changes in real time.

The work of FCC in 2003 has mainly been on coupling the geometry of the model with the adaptive finite element method. The solver of the elasticity equations has also been adopted to allow communication and integration with the user controlled virtual reality unit.

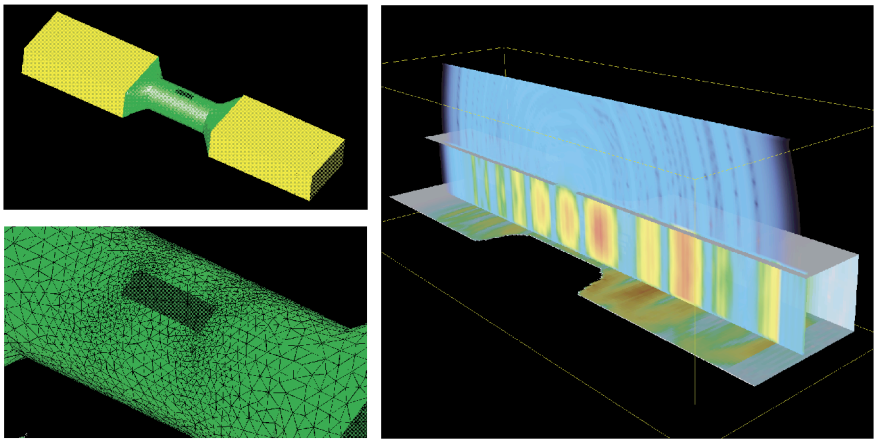
Computational Electromagnetics

In computational electromagnetics, FCC is sub-contracted by Parallel and Scientific Computing Institute, PSCI, project 24082-62591, for code development in the GEMS3 project.

The objective of this project is to develop a state-of-the-art software suite for Radar Cross Section (RCS), antennas and microwave applications.

In microwave systems it is common to use waveguides as transmission media for instance to feed antennas. Under certain conditions the waveguide problem can be solved separately and the solution be used as boundary data in the full simulation:

- A 3D hybrid grid of the waveguide geometry is created. Virtual, plane surfaces or ports which are orthogonal to the direction of propagation are used for excitation and registration of waveguide modes.
- A frequency-domain, 2D finite-element solver is used to calculate the mode field and propagation constant in the ports. The solution is transformed to time-domain and used as excitation in the full simulation by the Huygens surface technique.



A cylindrical slot antenna fed by rectangular waveguides (top left). The unstructured grid around the slot (bottom left). An instantaneous solution where part of the geometry is removed (right). In the vertical field plane we can also see the radiation through the slot. [Project 24082-62591 PSCI-CEM-Prog]

The Computational Physics Research Group

- Klas Samuelsson, PhD, mainly working on finite element technology
- Anders Ålund, Lic, mainly working on numerical methods and high speed computing
- Mats Larson, Docent in mathematics at Chalmers, scientific adviser at FCC

Klas Samuelsson

Anders Ålund

Mats Larson

Fatigue

General

Fatigue from a Statistical Point of View

Statistical methods can help to build a complete picture of the reliability of mechanical constructions with respect to fatigue resistance, and hence show where it is most efficient to take steps to improve the quality of a product.

The reliability is a combination of strength and loading. The strength is determined through fatigue tests, while the loadings are obtained through measuring loads in service or on proving grounds. The relation between loading, strength, and fatigue life is modelled using simple physical models. The determination of the strength as well as the loading is a difficult task, hence the two quantities are attached with a certain amount of uncertainty. A statistical perspective makes it possible to combine all uncertainties and variations in a total reliability analysis, and update the models with reports on failures in service. Especially the following areas can be identified:

- *Planning and evaluation of fatigue tests.* We apply well established statistical methods, like statistical design of experiments, regression analysis, prediction and confidence intervals, which we adopt to the particular engineering application.
- *Analysis of real service loads.* We use the theory of stochastic processes, RainFlow Count analysis, and work on questions concerning the relation between laboratory tests and service loads.
- *Uncertainties of empirical models.* A statistical methodology makes it possible to compare uncertainties of models with random variations in the loading and the material, in order to find an optimal complexity in the modelling.
- *Feedback of failure reports.* The use of Bayesian updating techniques makes it possible to improve future modelling of the phenomena. An important issue is to distinguish between systematic and random sources of variation.

Some Projects

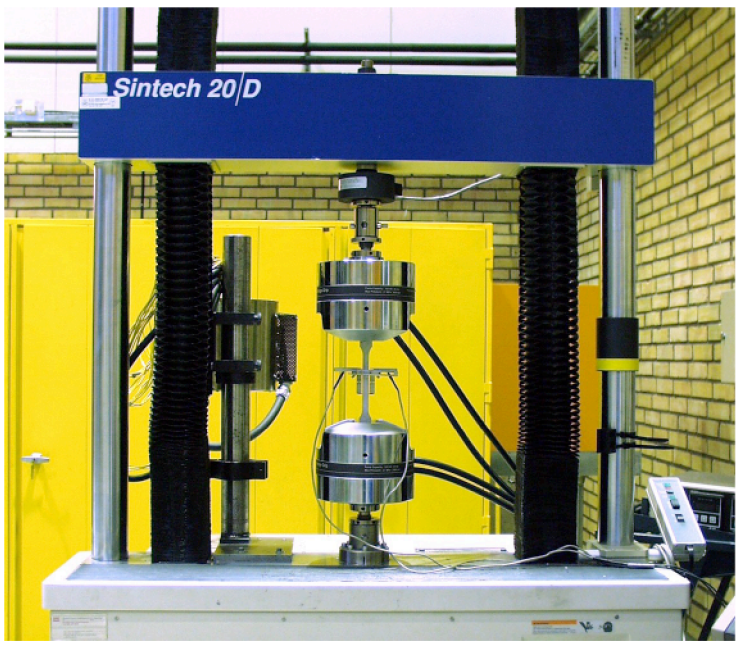
Statistics for experimenters

Material strength specifications are primarily based on experimental results, obtained from tests at the material manufacturer laboratory, their customers, or at specific test institutes. In order to get agreeable results, the measurement uncertainty must be evaluated to control both internal variations and laboratory specific biasses. Statistical theory is helpful for such evaluations and our group both give courses on the subject for industry, and help companies to evaluate measurement uncertainties for their specific equipment.

During 2003 we have given lectures on the statistical properties of measurement uncertainy within two different courses, and presented one introductory course on measurement system analysis (MSA), which is an important part of the automotive quality standard QS9000.

An important task in the overall evaluation of measurement uncertainties is comparisons between different laboratories. Round-Robin tests are regularily organised by different organisations: A number of specimens from the same material are distributed to different laboratories and after their tests the results are evaluated by means of statistical methods to get estimates on the within-laboratory variation, and the between-laboratory variation, respectively. The fatigue group is involved in such projects working with the statistical evaluation and interpretation of the results.

The evaluation of material strength properties within a company includes the use of statistical tools such as methods for comparisons of populations, modeling by linear regression techniques, and comparisons by means of the analysis of variance. These methods are often easily available in commercial software, but knowledge about the theory behind them is necessary for their correct use and interpretations. We have developed a three days course on these subjects for industrial practitioners which were given at one occasion during 2003.



A tensile test machine for evaluating material properties, for instance the ultimate tensile strength, the yield strength, and the elongation.

Extrapolation of load histories

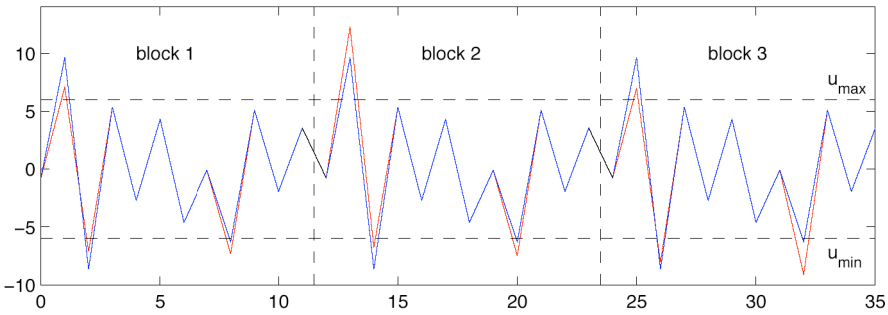
In fatigue life assessments both the material properties and the load characteristics are essential parameters. The life of a component can be experimentally found by performing fatigue tests. In order to get reliable predictions of the life in service, the tests should be performed using variable amplitude loadings that are representative for the service loads. A new method has been developed together with Bombardier Transportation for extrapolation of a measured load history to a longer time period, for example to a full design life. It is customary to use a measured load history, and repeat this load block until failure. This does not allow all possible load cycles. In the new method, load blocks are also repeated, however the largest maxima and the lowest minima of each block are regenerated in a random way based on statistical extreme value theory.

PhD projects

Several graduate students are connected to the group. Sara Lorén studies the statistical properties of fatigue limit problems, partly in cooperation with Sandvik Material Technology, Magnus Karlsson works in a project with Volvo Trucks, dealing with the problem of specifying markets with respect to their different severities, Johan Svensson studies the problem of air engine maintenance at Volvo Aero in co-operation with a parallel PhD project on optimisation, Gwenaëlle Genet works with descriptions of fatigue loads in a project with PSA in France, and Jenny Andersson studies statistical properties of point processes with applications in fatigue properties of the grain structures in metallic materials.

Visitors

Professor Igor Rychlik, Lund, works part time in the group and during his visits in Göteborg the group organises seminars for discussions about different statistical aspects on fatigue. The PhD student Bettie Joossens from Belgium has visited the group occasionally in connection to her work with Ovako steel.



An example of extrapolation of a load history. Three repetitions of a measured load block (blue), compared to three extrapolated blocks (red). The horizontal dashed lines are the threshold levels, where the extrapolation starts.

The Statistical Fatigue Research Group

The statistical fatigue research group do consulting and perform research tasks, especially for the engineering industry. The group consists of

- Thomas Svensson, PhD, mainly working on variable amplitude fatigue, measurement uncertainty, and statistical methods in engineering
- Pär Johannesson, PhD, mainly working on modelling of fatigue loads, rainflow count analysis, and reliability in engineering
- Magnus Karlsson, PhD student, virtual description of road environment of trucks, independent of vehicle and driver
- Jacques de Maré, Professor in mathematical statistics at Chalmers, scientific adviser at FCC

Thomas Svensson

Pär Johannesson

Magnus Karlsson

Jacques de Maré

Optimization

General

The area of industrial applications of optimization is very broad. Optimization problems arise as stand-alone problems in many contexts, and optimization is used in a large variety of fields in applied mathematics and natural, economical and technical sciences in order to model, solve and analyze (sub)systems.

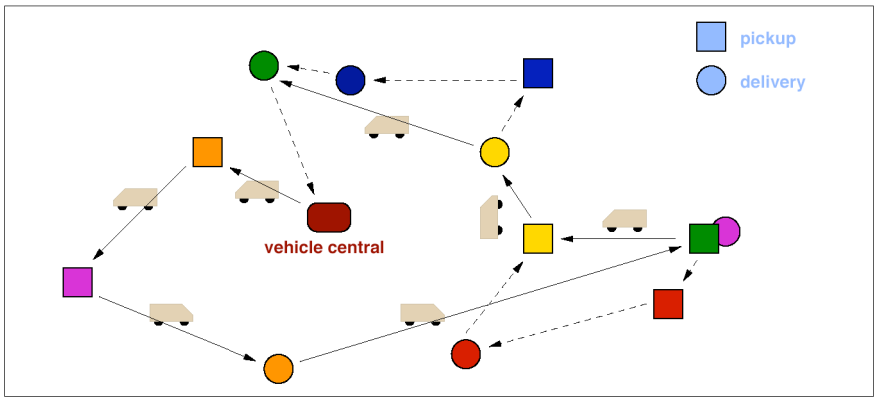
The optimization group at FCC is anticipated to grow, both because of more industrial contracts and, not the least important, because more and more applied projects at FCC need efficient large-scale optimization.

Engineering Optimization

In engineering optimization, it is quite often the case that the objective value is a measure of the performance of a system which is described in terms of simulations of a physical or chemical process. The variables in the optimization problem correspond to design parameters that are used as input to the simulation, which may be in the form of a PDE/ODE system. For some simple such models, explicit (or numerical) derivatives of the "responses" (that is, the result of the simulation as a function of the parameter values) are possible to obtain, but they are usually not explicit outputs from the simulation. Since derivative information is beneficial for a successful optimization, a current project at FCC is the development of a toolbox in engineering optimization, which will integrate the simulation and optimization through the calculation of derivative information. As an application, the efficiency profile of the motor for a passenger car is studied in a master's project started in 2003 with two Chalmers students.

Logistics

The potential for optimization of resources in the area of logistics is huge. Through Göteborgs Handelskammare we have received an indication of several branches where the introduction of planning tools utilizing mathematical optimization would lead to a potentially large increase in efficiency and profitability. Examples are peoples' transportation, refuse collection and transportation of fragile products.



A vehicle route being adjusted for newly ordered passenger trips.

Some projects

Optimization of peoples dial-a-ride transportation service

The transportation service for old and disabled persons is a recurring objective for savings. Therefore it is of increasing importance that the resources reserved for these activities are efficiently utilized while the service level for the customers should be held sufficiently high.

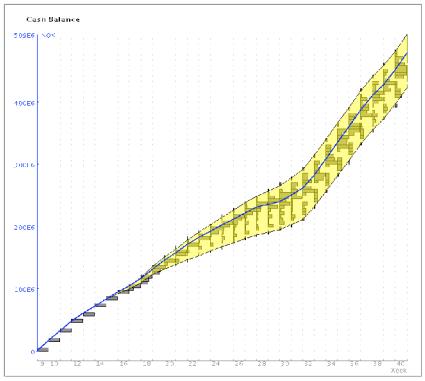
For PLANit Sweden AB, Göteborg, which manufactures systems and services for taxi and bus companies and municipal booking centrals, we have evaluated solution algorithms for on-line routing of peoples dial-a-ride transports using real sample data. In the system considered each passenger trip is allocated to a vehicle route at the moment of the order, and each new trip allocated to a route may possibly change the route previously planned. This flexibility is of utter importance for the planning system to work effectively.

The goals for the optimization which can easily be adjusted are to reduce unnecessary travel time for people and time occupied for vehicles. Also various types of restrictions on trips and routes are automatically handled. By matching information about the individually designed traveller service with vehicle resource information the algorithms employed manage to make an efficient, robust and appropriate transportation planning.

Optimization of Power Systems under Uncertainty

The recent deregulation of the power market has led to a new situation for the power producers which necessitates the development of new planning and decision tools, incorporating the management of portfolios of energy contracts, among others. This project focusses on the seasonal planning of a power system with hydro and thermal power generation and sales and purchase of power. It considers a time horizon of 1-1.5 years, with a time resolution of one week. The stochasticity of the reservoir inflows and the electricity spot price have a large impact on the decision model on this time scale, and is therefore explicitly modelled.

The project has developed the tool SPOT (seasonal planning optimization tool) for



Probability distribution of cash balance for each time period with median (blue).

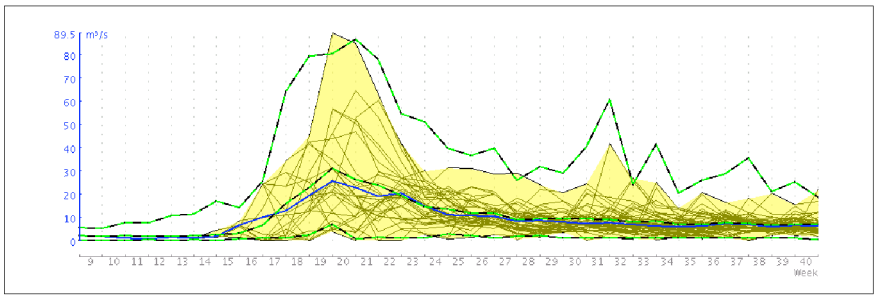
decision-making in power systems planning under uncertainty. Users can make prognoses for, e.g., cash flows, energy production, water levels in reservoirs, and the amount of energy bought and sold, for each week during the planning period. The prognoses are graphically and numerically presented for all the different future scenarios considered.

The optimization model resulting from the problem definition is a multi-stage stochastic program defined on a scenario tree, which represents the uncertainty of inflow and spot price during each week of the planning period. It is a very large scale optimization problem, which calls for advanced decomposition methods and high-performance computing. A stochastic model adapted to the simulation of the reservoir inflow and electricity spot prices and based on historical, weekly data has been developed; it employs moment matching and in order to receive an optimization model that is computationally managable the scenario tree is reduced using principal component analysis. The optimization techniques then employed are based on nested Benders decomposition which attempts to partition the model into one planning problem for each week and scenario; these problems are linked through balance constraints for the water and energy systems and for the contract portfolios.

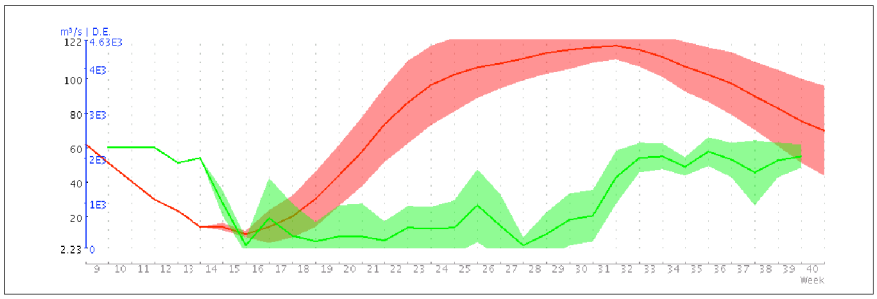
The project runs from May 2002 until April 2004 and is a joint project between Optimization Partner Stockholm AB, Lund Institute of Technology, and FCC. It is financed by the Swedish Energy Agency (STEM) and the industrial partners Elforsk, Sydkraft, Fortum Power and Heat OY, and STM Research.

PhD projects

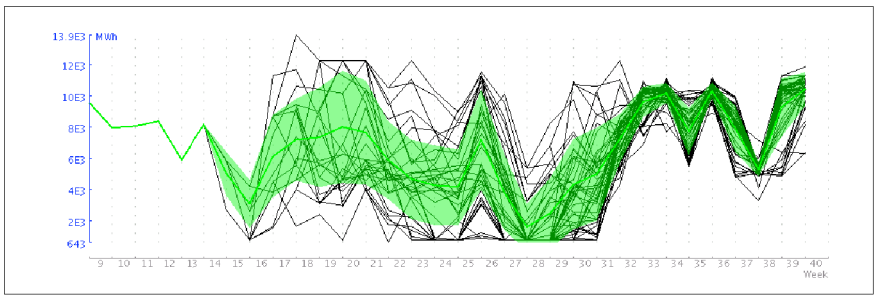
Two PhD students at Chalmers Mathematics have received co-advisement from FCC: Niclas Andréasson (Cost effective motor maintenance) and Fredrik Altenstedt (Asset liability management).



A scenario tree representing inflows to a reservoir with median (blue). Maximum, mean, and minimum values of the corresponding historical time series per time period indicated by green-black-dashed lines.



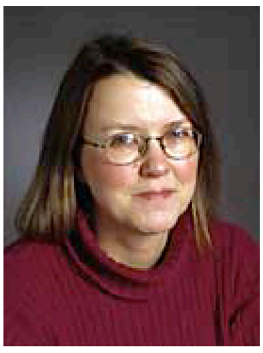
The mean value plus/minus standard deviation per time period of the content in a reservoir (red) and the flow through an immediate downstream hydro power station (green).



A scenario tree representing the production in a hydro power station per time period. Mean values plus/minus standard deviation indicated in green.

The Optimization Research Group

- Ann-Brith Strömberg, PhD, mainly working on combinatorial optimization and optimization under uncertainty
- Michael Patriksson, Professor in applied mathematics at Chalmers, scientific adviser at FCC



Ann-Brith Strömberg

Michael Patriksson

Quality Engineering

General

Sensitive product and production concepts often result in quality problems with delays in market introductions and lost revenue as a consequence. The opportunity to simulate and visualize variation and tolerance results, combined with tools for diagnosis are important success factors to improve quality. Less variation in products and processes gives a substantial return on investments in form of lower costs for adjustment, rejects and claims. Furthermore, since quality is one of the most important customer decision factors, employing quality as a part of the business strategy is highly motivated. This challenge, to produce high-quality products to low cost and with short lead-times, has increased the focus on quality engineering over the last decade.

Most organizations find it difficult to provide products without quality flaws, since manufacturing imperfections cause variability between different units of the same product. Additionally, during the expected life span of the product, deterioration and variability in environmental variables will cause variability in the product performance. A modern quality program aimed towards reducing variability provides tools for robust design and statistical process control combined with methods for diagnosis.

Quality engineering encapsulates all activities striving towards improved quality, including a number of areas and disciplines. Since mathematics is the most versatile of all sciences, it is uniquely well placed to contribute in all individual areas of quality engineering. Also, since a number of design tasks today are multidisciplinary in its character, including a large number of parameters, mathematics plays a critical role in the area of multidisciplinary optimization.

FCC operates to support a systematic reduction of variability in processes and products in the following key areas:

- Robust design
- Inspection planning optimization
- Process control and diagnosis
- Root cause analysis

Some projects

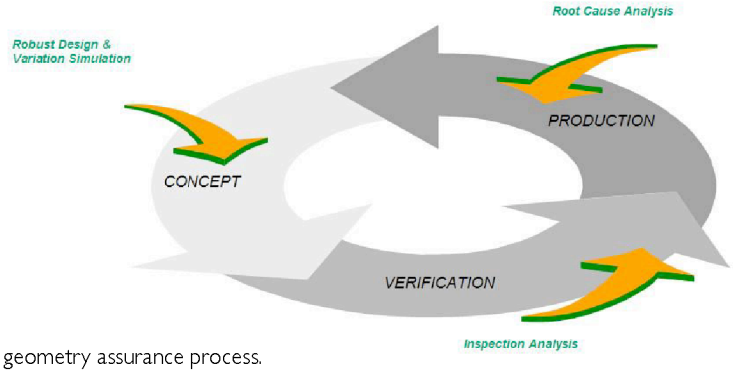
3D Tolerance Management

The project 3D TM within the Nutek's program "IT i verkstadsindustrin" started in 1997. The project is run by Wingquist Laboratory at Chalmers, IVF Industrial Research and Development Corporation, FCC, and Volvo Car Corporation.

The aim of the project is to reduce geometrical variation in assembled products in the automotive industry and others. In particular, geometrical variation in the structural frame of an auto body, body in white, causes quality problems in the final products such as wind noise, water leakage, door closing effort, gap and flush variation. The three focus areas, illustrated in the figure below, are; (I) robust design and variation simulation, (II) inspection planning and analysis, and (III) assembly diagnosis. The project combines advanced research with implementations in industrial environments.

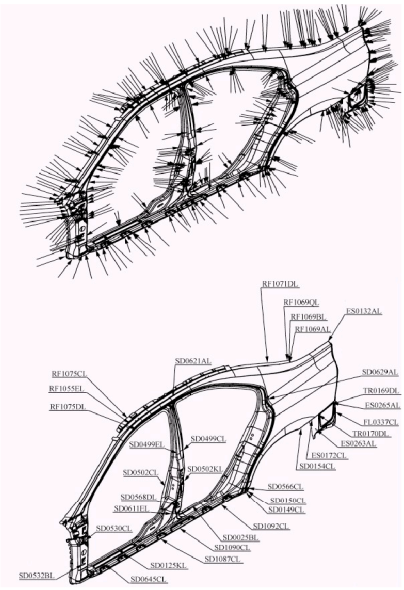
The research group comprises the project manager Professor R Söderberg and Dr L Lindkvist from the Product and production development department at Chalmers, Dr J S Carlson from FCC, MSc F Wandebäck and MSc P-J Wahlborg from IVF.

Robust design and variation simulation: We use statistical Monte Carlo simulation, sensitivity analysis and contribution analysis from our partner RD&T Technology to make the product insensitive to manufacturing and assembly tool variation. This reduces the need for costly physical prototypes and test series.



The geometry assurance process.

Inspection planning and analysis: We develop methods and support tools for intelligent inspection preparation. The motive is to gather as much information about the product and the process as possible with minimum number of inspection points.



Inspection point reduction in action on S60 car body side.

SPC and assembly root cause analysis: We develop statistical methods to make root cause analyses on the product to find and correct problems in the manufacturing and assembly process. The motive is fast identification and correction of problems and increased knowledge about product/process correlation.

Measurement System Analysis

Today, all subcontractors of the automotive industry are assumed to have implemented the quality management system QS 9000. An important part of QS 9000 is the measurement system analysis which quantifies the capability of a measurement system. The aim of this project is to adopt and develop the analysis manual to CADCAM based measurement systems and its equipment, when using coordinate measurement machines.

Path Planning of Rigid Bodies and Industrial Robots

A long term vision within the field of production technology is the virtual factory, with high level of accuracy regarding realism and functionality. Early programming, simulation and visualization of virtual production equipment make it possible to reduce the ramp up time in the real factory. Despite that modern industries use virtual prototypes to replace physical prototypes, visualize assembly processes and program industrial robots off-line, the full potential of the virtual factory is still not reached. A major limitation is programming time. Most programming of motions and paths for robots and equipment is still generated manually, since the existing support for automatic path planning is very limited.

Therefore, this project aimed at automatically finding collision-free paths for robots, from initial configurations to final configurations, with that of minimizing cycle time, path length and joint wear. Visualization, simulation and verification of assembly processes are also areas were the needs for automatic path planning is increasing with higher demands on reduced start-up times.

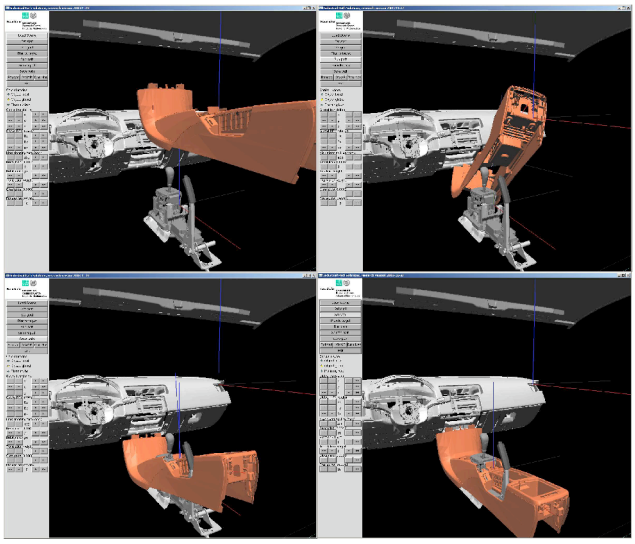
FCC supports the following path planning applications:

- Assembly visualization/verification/design
- Robot handling
- Arc welding, sealing and painting
- Spot welding
- Coordinate measuring (CMM)
- Path coordination of multi-robots
- Non-nominell path planning

Analysis of maneuverability in narrow spaces

The project with our partner Volvo Car Corporation has resulted in simulation software for automatic path planning, viewed below. The software is based on a virtual 3D model describing the kinematics and the geometry in the assembly cell, interacting with a collision tester.

FCC has also worked on arc-welding applications with ABB Robotics.



Is it possible to assembly the tunnel? The FCC path planner finds a solution in less than 5 minutes. Even an experienced simulation engineer will struggle for days with this assembly verification (model by courtesy of Volvo).

The Quality Engineering Research Group

- Johan Carlson, PhD, Vice Director FCC
- Robert Bohlin, PhD, mainly working on robotics
- Rikard Söderberg, Professor in product and production development at Chalmers, Director Wingquist Laboratory, scientific adviser FCC

Johan Carlson

Robert Bohlin

Rikard Söderberg

Systems and Data Analysis

General

The FCC research in systems and data analysis focuses on (1) signal and image analysis, (2) systems biology, and (3) finance and insurance mathematics.

In signal and image analysis, mathematical methods and algorithms are developed for detecting the *presence* of objects or phenomena, for *enhancement*, i.e., supressing unwanted features or strengthening relevant features, for *classifications* of objects and patterns, and for *compression*, i.e., reducing the data size of the signal, usually to the price of losing some information. We also consider aspects on traffic flow of signals, e.g., in communication networks.

Systems biology is an emerging scientific field that aims at system level understanding of biological processes. This understanding is of crucial importance in both the biotech, pharmaceutical, and bioengineering industry. In the biotech and pharmaceutical industry enhanced understanding of disease mechanisms is of vital importance to successfully find new candidate drugs and drug targets. In the bioengineering industry improved biological process knowledge is the key to better yield and product quality.

In finance and insurance, mathematics is nowadays an indispensable tool to solve a wide range of problems, e.g., related to time series analysis and risk. Disciplines as probability theory, statistics, scientific computing, and partial differential equations are used to develop models of financial markets, price derivative instruments and insurance contracts, constructing portfolios and designing methods to assess the risk of a portfolio.

As described on pages 6 - 7, FCC and ITWM have made a special effort in this field. FCC has also recruited a new staff member in finance and insurance mathematics.

Some projects

Surface inspection

An important application of image processing is in *automatic visual surface inspection*. In all production systems, defects appear on the products. To discover these defects as early as possible in the production process is vital. Up to recently, all visual quality control has been done by human inspection. But with the advance of computers and image processing, automatic visual surface inspection has become a very tractable alternative. An automatic inspection system usually consists of one or several cameras, aquiring high quality images of the surface of the object under inspection. These images are continuously fed to one or several computers where they are processed by advanced image analysis algorithms, with the aim of detecting defects visible on the surface. The advantages with such a system are:

- It is objective compared to human inspection, where different individuals may detect different defects
- It is consistent; the result is always the same, in contrast to human inspection
- It is usually faster
- It enables gathering statistics on the occurance of various defects

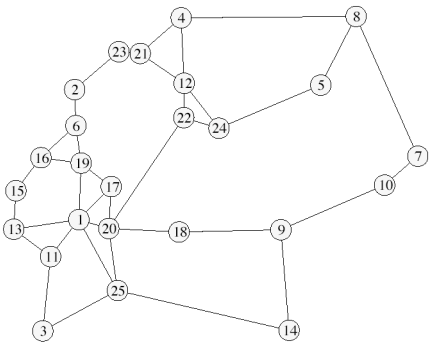
Inspection systems are available for, but not limited to, materials such as paper, textiles, wood, metal, plastics and rubber.

FCC and ITWM are together doing a project with a Swedish company aiming at constructing a quality inspection system for leather hides early in the production process. The problem may be divided into two parts: (1) detect the relevant defects, and (2) determine the quality class from the positions of the detected defects.

During 2003, the second problem was addressed in a pre-project and sucessfully solved. Thereafter, the first part was approached in another pre-project. Some of the defects turned out to be very challenging, and are currently under investigation.

Analyzing data networks using processor sharing queues

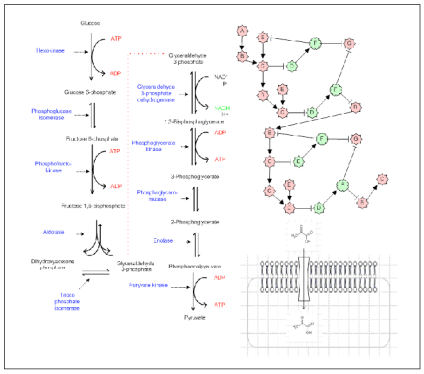
This project was concerned with computing average delays in TCP data networks (such as Internet). The main focus was on designing approximate methods able to handle large networks with tens or hundreds of nodes, for which simulations become impossible. To achieve such a method, two approximations were made. First, the TCP traffic is modelled by ideal fair sharing, in which all file transfers in a networks instantaneously get their fair share of each links' capacity. Yet, this model is presumably too complicated for an arbitrary network, so the *bottleneck method* was delevoped, in which the bottleneck link in the network is identified (given its statistical traffic intensities), and all file transfers passing through this link are assumed to be delayed by this link only. The corresponding delays may then be computed from the well established queuing theory for a single link. The corresponding traffic is then subtracted from the network, and the procedure is repeated on the remaining (virtual) network. Matlab simulations were made on small networks with up to six nodes, and in each case the relative errors was within 5 %. Applying the method on networks with up to 50 nodes demonstrated that the metod is very fast, and indicated that with an efficient implementation, it should be possible to analyze a network with thousand nodes in less than one minute on a standard PC.

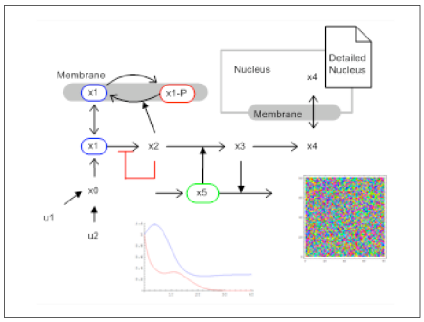


A test network with twentyfive nodes.

Strategic project in systems biology

The Swedish Foundation for Strategic Research finances an initiative in systems biology at FCC with a 5MSEK grant for a scientific leader (Dr Mats Jirstrand) and the build up of a research team. In accordance with the FCC model, the Centre will at the same time seek industrial partners for contract research and work in applied projects defined by companies or public institutes on a commercial basis. FCC has a very close collaboration with InNetics AB - the developers of PathwayLab.





Control and Dynamic Systems

FCC has the ability to take on research and applied projects in modeling, identification, and control of industrial systems. The competences at the centre covers component-oriented modeling of complex physical systems using equation based modeling tools like Modelica, advanced system identification techniques, and control system design.

A project in this field has studied the interaction between system variables as a boundary condition formulation between different system parts.

Pricing of Exotic Options

In recent years the number of various complex derivatives, also known as exotic options, has increased considerably on the market. This development calls for efficient pricing routines for exotic options. Typically, the pricing of exotic options amounts to computing integrals in high dimensions. In a project together with Front Capital Systems, FCC and Chalmers have developed Monte Carlo and finite different methods to estimate the price of some complex barrier and average options.

ALM by simulation

The active management of pensions funds calls for the analysis of actual market conditions and the impact of changes for selecting the appropriate long-term strategy. At the end of 2003, FCC and the Second Swedish National Pension Fund AP2 started a joint project to develop, formulate, and complete an asset liability simulation model for pension fund management. The work will be done by AP2 and FCC together with Fraunhofer ITWM.

The Systems and Data Analysis Research Group

- Fredrik Ekstedt, Lic, mainly working on signal and image analysis
- Mats Jirstrand, PhD, mainly working on systems biology and systems & control
- Per Hörfelt, PhD, mainly working on finance and insurance mathematics
- Gerald Kroisandt, PhD, ITWM department of finance mathematics
- Tomas Gustavsson, Professor in imaging and image analysis at Chalmers, scientific adviser at FCC


Fredrik Ekstedt


Mats Jirstrand


Per Hörfelt


Gerald Kroisandt


Tomas Gustavsson

Bioinformatics and Biostatistics

General

With the massive amount of biological and medical data generated today the biotech and pharmaceutical industry is faced with a number of new problems. Besides handling the sheer volume of data, the types of analyses one wants to perform are often strikingly different than what was anticipated just a few years ago.

Bioinformatics combines genetics, mathematics and computer science to handle the sequence and gene expression data generated by the biotech and pharmaceutical industry. The research within the field involves the development of tools to model, analyze, and visualize complex biological data.

Biostatistics is partly overlapping with bioinformatics and is concerned with the development and use of statistical methods for the analysis of biological data. Biostatistics and in particular survival analysis can be used to discover genetic and environmental effects on the life length of individuals or in the age at onset for diseases. Statistical genetics aim at pinpointing the position in the genome containing genes affecting a certain disease.

Important research areas include:

- Comparative genomics
- Computational sequence analysis
- Functional genomics
- Proteomics
- Biostatistics
- Statistical genetics

The bioinformatics group at FCC is funded by the Swedish Foundation for Strategic Research in a project that runs along the same lines as in the programme "Future Scientific Leader". Scientific director is Dr. Marina Alexandersson. She joined FCC in September 2002 to build a group in Bioinformatics.

Some projects

Genetic causes in the development of type II diabetes

Biostatistics and in particular survival analysis is involved with discovering genetic and environmental effects on the life length of individuals or in the age at onset for diseases.

Human diseases can be divided into monogenic and complex diseases. A monogenic disease is caused by one or several genetic variations in only one position (locus) on the human genome, while a complex disease is caused by genetic variations at several positions on the genome and also often in a complex interaction with one or several environmental factors. The complexity of the genetic effect on the disease development is described in terms of different populations, determining the rareness of the mutations (allele frequencies), and type of disease (genetic model).

Medical data consist of measurements of genes, either individual measurements or measurements of genetic similarities between relatives, at prespecified positions on the human genome. The overall aim of an analysis is to find the position or positions which cause the disease in the studied population.

We have so far used two approaches to reach that goal. In the first we have used genetic measurements on individuals together with the age-at-onset in the disease. This has led to a description of genetic variants that effect the time to the development of diabetes. Of particular interest is the genetic-environmental effects, and whether for instance smoking interacts with certain genes on the development of diabetes, or whether there are gender differences. This has led to new findings, which might potentially influence clinical practice.

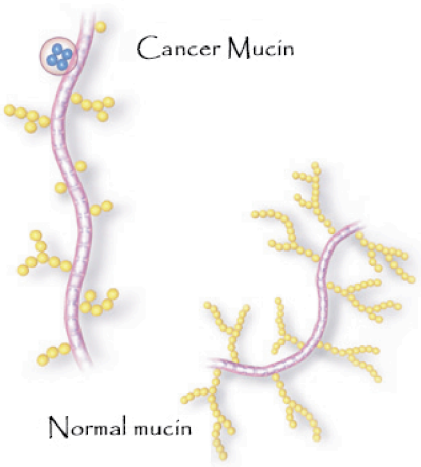
A slightly different approach is to use family data, using so called IBD counts, for affected relatives. The aim in this approach is to develop tools to study a two-locus interaction on the development of a complex disease, meaning that we look for genetic variations at two different positions on the genome, simultaneously. The methods should be robust with respect to the type of human population and the type of disease. This is especially important for complex diseases, such as type II diabetes, since the genetic model for those is in general largely unknown.

Partners:

i) The Wallenberg Laboratory, Malmö Academical Hospital, Lund University.

ii) Mathematical Statistics, Centre for Mathematical Sciences, Lund university.

The puffer fish *fugu rubripes* is a popular model organism of human genetics.



Mucin proteins protect cells from injury. Cancer disrupts this function.

Bioinformatic identification of mucin proteins

Inflammatory and infectious diseases, cancer and metastasis are examples of disease processes where the communication between the cell and its surroundings has gone astray. Identification of factors involved in this interaction helps the understanding and development of therapeutic treatments of such diseases.

Mucin proteins serve as diffusion barriers that protect cells from infection, dehydration, and chemical or physical injury, and as lubricants that help materials through various passages such as the respiratory and digestive tracts. The aim of this project is to identify novel mucin proteins, using Fugu fish as model organism.

Fugu rubripes is a poisonous puffer fish, commonly seen in sushi restaurants. Its similarity to the human genome makes it a popular model organism. Puffer fish have roughly the same number of genes, with most of them having human counterparts, but the genome size is about seven times smaller than that of human. The reason is that the genome is more densely packed with significantly less amount of "junk DNA", but this simplifies the detection and analysis of functional elements immensely. Fugu has helped reveal nearly 1,000 novel human genes already.

Method: A mucin is among other things characterized by a part called the mucin domain, which is simply a subsequence of amino acids in the protein with certain characteristics. For instance, the domain is often composed of repetitive segments with abundant representation of the amino acids Serine, Threonine and Proline. However, the actual sequence tends to be poorly conserved, and as a consequence, similarity based database searches cannot be relied on.

In this project we developed an algorithm, implemented in a software we call MPRED, that uses the compositional bias characteristic of mucin domains to predict potential mucins in a protein database. The method is built on a hidden Markov model that is currently specialized for mucin domains, but that can easily be extended to include more features or altered to identify other domains. The algorithm runs through the protein sequence and determines which amino acids segments belong to a potential mucin domain along with a probability indicating a confidence in the prediction.

The project is a collaboration with the Department of Medical Biochemistry at the Gothenburg University.

The Bioinformatics Research Group

- Marina Alexandersson, PhD, reseach leader
- Dragi Anevski, PhD, mainly working on biostatistics
- Sofia Andersson, PhD, mainly working on bioinformatics
- Sture Holm, Professor em, Chalmers, scientific adviser FCC

Marina Alexandersson

Dragi Anevski

Sofia Andersson

Sture Holm

Årsredovisning

för tiden 1 januari 2003 - 31 december 2003

Resultaträkning (kSEK)	030101-031231
Intäkter	
Erhållen basfinansiering	6 409
Fsg tjänster - ind proj	6 972
Fsg tjänster - publ proj	4 484
Övriga intäkter	440
Summa intäkter	**18 304**
Kostnader	
Personalkostnader	-10 648
Konsulter	-3 779
Lokaler	-1 650
Kontorskostnader	-1 086
Resor och representation	-531
Avskrivningar enligt plan inventarier	-422
Summa kostnader	**-18 116**
Rörelseresultat	**188**
Resultat från finansiella investeringar	
Ränteintäkter och liknande	59
Räntekostnader och liknande	-31
Resultat efter finansiella poster	**216**
Årets skatt	**-132**
ÅRETS RESULTAT	**84**

Balansräkning (kSEK)	031231
Anläggningstillgångar	
Inventarier	304
Datorer	253
Summa anläggningstillgångar	**557**
Omsättningstillgångar	
Likvida medel	4 634
Kundfordringar	1 810
Förutbetalda kostnader och upplupna intäkter	753
Summa omsättningstillgångar	**7 197**
SUMMA TILLGÅNGAR	**7 754**
Eget kapital och skulder	
Balanserat resultat	73
Årets resultat	84
Summa eget kapital	**157**
Kortfristiga skulder	
Leverantörsskulder	1 787
Övriga kortfristiga skulder	1 845
Upplupna kostnader	3 965
Summa kortfristiga skulder	**7 597**
SUMMA SKULDER OCH EGET KAPITAL	**7 754**

Styrelsen för Stiftelsen Fraunhofer-Chalmers centrum för industrimatematik, FCC, får härmed avge följande redovisning över verksamheten under tiden 1 januari 2003 – 31 december 2003, stiftelsens andra verksamhetsår.

Stiftelsen bildades av Chalmers och Fraunhofersällskapet i juni 2001 och registrerades av Länsstyrelsen i Västra Götalands län i oktober 2001 som en svensk näringsdrivande stiftelse. Stiftelsen skall enligt affärsplan från mars 2001 bygga upp en verksamhet som år 2004 omsätter två miljoner euro och omfattar arton anställda.

Årets omsättning har varit drygt arton miljoner kronor. Antalet anställda har ökat från tolv personer (varav tre kvinnor) den 31 december 2002 till sjutton personer (varav fem kvinnor) den 31 december 2003. Stiftelsen har hyresavtal med Fastighets KB Forskarbyn omfattande 540 kvm i Chalmers Teknikpark till den 31 mars 2005. Tidigare andrahandskontrakt med Chalmers Industriteknik upphörde den 30 september 2003.

Fraunhofersällskapet har vid möte i november 2003 beslutat öka sin tidigare beslutade finansiering av centret för år 2004 samt beslutat reservera samma belopp för år 2005

Styrelse och ledning den 26 februari 2004. Bakre raden: Dieter Prätzel-Wolters, Claes Ekman, Jöran Bergh. Mittenraden: Helmut Neunzert (vice ordförande), Johan Carlson (biträdande föreståndare), Lars-Göran Löwenadler. Främre raden: Uno Nävert (föreståndare) Peter Jagers (ordförande), Tomas Lefvert, Gunnar Andersson.

FÖRVALTNINGSBERÄTTELSE

Stiftelsen Fraunhofer-Chalmers centrum för industrimatematik skall utveckla och anpassa matematiska metoder för industrin. Stiftelsen bedriver konkurrensneutral forskning och marknadsföring med finansiering från grundarna och genomför projekt definierade av företag och offentliga finansiärer på kommersiell grund.

Rörelsens intäkter har uppgått till 18 304 kSEK. Av detta utgör 38% industriprojekt, 25% offentliga projekt, 35% finansiering från grundarna och 2% övrigt.

Årets resultat efter skatt är 84 kSEK. Eget kapital uppgick den 31 december 2003 till 157 kSEK. Enligt stiftelseurkunden har grundarna tillskjutit ett kapital på 50 kEUR vardera. Detta skall återbetalas senast den 31 december 2004.

Stiftelsens styrelse har under verksamhetsåret sammanträtt två gånger. Ersättning har utgått till ordföranden med 7 500 kronor per möte och till övriga ledamöter med 5 000 kronor per möte man deltagit i.

Stiftelsens ställning och resultatet av dess verksamhet framgår av efterföljande resultat- och balansräkningar, vilka utgör en integrerad del av årsredovisningen.

Göteborg den 26 februari 2004

Peter Jagers, ordförande
Jöran Bergh
Helmut Neunzert, vice ordförande
Dieter Prätzel-Wolters
Gunnar Andersson, adjungerad
Claes Ekman, adjungerad
Tomas Lefvert, adjungerad
Lars-Göran Löwenadler, adjungerad

Räkenskaperna har granskats av Deloitte.

Result (kEUR)	030101-031231
Income	
Basic funding	705
Projects - industry	767
Projects - public	493
Others	48
Total income	**2 013**
Cost	
Staff	-1 171
Consultants	-416
Premises	-181
Office	-119
Travel and entertainment	-58
Depreciations	-46
Total cost	**-1 993**
Result of business	**21**
Result of financial investments	
Interest and similar income	7
Interest and similar cost	-3
Result including financial investments	**24**
Tax	**-15**
TOTAL RESULT	9

Balance (kEUR)	031231
Fixed assets	
Furniture	33
Computers	28
Sum of fixed assets	**61**
Current assets	
Cash	510
Customer claims	199
Prepaid expenses and accrued income	83
Sum of current assets	**792**
TOTAL ASSETS	853
Equity capital and debts	
Balanced result	8
Result of the year	9
Total equity capital	**17**
Short-time debts	
Debts to suppliers	197
Other debts	203
Accrued expense	436
Sum of short-time debts	**836**
SUM OF DEBTS AND EQUITY CAPITAL	853

Appendix

Presentations / Conferences

M Alexandersson:
Topics in Bioinformatics, ITWM forskardagar, Kaiserslautern, February 27, 2003.

M Alexandersson:
Bioinformatics at the Fraunhofer-Chalmers Centre, Bioscience seminar at Chalmers, March 18, 2003.

M Alexandersson:
Cross-species gene finding and alignment with generalized hidden Markov models Statistik-seminarium, Matematisk statistik, Stockholms Universitet, April 23, 2003.

M Alexandersson:
Comparing the human and mouse genomes,IBS Nordic Regional Conference, Ultuna, June 13, 2003.

M Alexandersson:
Mathematics in DNA sequence analysis, 2nd Nordic summer school for female PhD students in mathematics, Chalmers, August 9, 2003.

M Alexandersson:
Gene finding, alignment and generalized pair hidden Markov models, 54th ISI Session, Berlin, August 19, 2003.

M Alexandersson:
How many genes do we have? Answers given by cross-species gene finding algorithms.The 6th annual functional genomics symposium, Chalmers, August 29, 2003.

M Alexandersson:
Gene finding using mathematics, MY work-shop, Matematik, Chalmers, September 24, 2003.

M Alexandersson:
How many genes do we have? Answers given by cross-species gene finding algorithms, Med-icinsk epidemiology och biostatistik,Karolinska Institutet, October 23, 2003.

M Alexandersson:
Bioinformatics at FCC, AstraZeneca R&D, Lund, November 25, 2003.

M Alexandersson:
Determining gene structure and finding trans-cription start sites, Medicinsk kemi, Göteborgs Universitet, December 3, 2003.

M Alexandersson:
Bioinformatik vid Fraunhofer-Chalmers cen-tret, Klinisk neurovetenskap, Mölndals sjukhus, December 5, 2003.

J S Carlson:
Banplanering och flexibel automatisk off-lineprogrammering för geometrisk mätutrust-ning. Komplex processes first call,Vinnova, Stockholm, June 18, 2003.

J S Carlson:
Non-nominell Path Planning. Wingquist annual seminar day, Göteborg, September 30, 200.

J S Carlson:
Non-nominal Path Planning. ProViking second call, SSF, Stockholm, September 30, 2003.

J S Carlson:
Application of Non-nominal Assembly System Analysis. Panel discussion on Assembly Systems, ASME International Mechanical Engi-neering Congress & Exposition, Washington DC, USA, November 19, 2003.

J S Carlson:
Non-nominal Path Planning. ProViking second call, SSF, Stockholm, December 4, 2003.

M Jirstrand:
PathwayLab - A Software for Biochemical Systems Modeling and Analysis, Biological Engineering Division, MIT, Cambridge, USA, September 18, 2003.

M Jirstrand:
Systems Biology - Some Basic Ideas, Division of Automatic Control, Linköping University, October 10, 2003.

M Jirstrand:
Systemteori och reglerteknik - från gasturbi-ner till biokemi, Invited Lecture at The Swe-dish National Network in Applied Mathema-tics Meeting, Marstrand, October 17, 2003.

M Jirstrand:
Computational Biology at the Fraunhofer-Chalmers Centre, Workshop on Mathematical Aspects on Systems Biology, Göteborg, November 13-15, 2003.

M Jirstrand:
Systems Biology – An Overview, Fraunhofer ITWM, Kaiserslautern, Germany, November 18, 2003.

M Jirstrand:
Modelica - An Equation Based Language for Complex Dynamic Systems Modeling, Fraunhofer ITWM, Kaiserslautern, Germany, November 19, 2003.

M Jirstrand and J Roll:
Applicability of Nonlinear System Identification Techniques to Biochemical Networks, Workshop on Cellular Networks, Norrköping, December 15-16, 2003.

M Jirstrand and J Gunnarsson:
PathwayLab - A Software for Biochemical Systems Modeling and Analysis, Workshop on Cellular Networks, Norrköping, December 15-16, 2003.

M Patriksson:
Global optimality conditions for discrete and nonconvex optimization, with applications to Lagrangian heuristics and column generation. Talk at the 18th International Symposium on Mathematical Programming, Copenhagen, 18-22 August, 2003.

A-B Strömberg:
Optimization under uncertainty and applications. Talk at "Forschungstag" at Fraunhofer ITWM, Kaiserslautern on February 27, 2003.

Publications

M Alexandersson, S Cawley, L Pachter:
SLAM - Cross-species Gene Finding and Alignment with a Generalized Pair Hidden Markov Model. Genome Res. 13(3), 496-502, 2003.

S Cawley, L Pachter, M Alexandersson:
SLAM webserver for comparative gene finding and alignment. Nucl. Ac. Res. 31(13), 3507-09, 2003.

F Lam, M Alexandersson, L Pachter:
Picking Alignments from (Steiner) Trees. J. Comp. Bio. 10(3-4), 509-520, 2003.

D Anevski:
Estimating the derivative of a convex density. Statistica Neerlandica, 57(2), 245-257, 2003.

V Lyssenko, P Almgren, D Anevski, R Perfekt, K Lahti, M Nissén, B Isomaa, B Forsén, N Holmström, C Saloranta et al:
Predictors of and longitudinal changes in insulin sensitivity and secretion preceding onset of type 2 diabetes. Submitted. 2003.

J S Carlson:
Geometrical Inspection Point Reduction Based on Combined Cluster and Sensitivity Analysis. ASME International Mechanical Engineering Congress & Exposition, Washington DC, USA, November 19, 2003.

P Hörfelt:
Extension of the Broadie, Glasserman, and Kou Continuity Correction, Finance and Stochastic, vol. 7, pp. 231-243, 2003.

P Hörfelt:
Probabilistic Interpretation of the Theta-Method, Letters of Probability and Stochastics, vol. 62, pp. 117-122, 2003.

P Hörfelt:
Pricing Discrete Barrier Options Using Lattice Random Walks. Mathematical Finance, vol. 13, pp. 503-524, 2003.

P Hörfelt :
Geometric Bounds on Certain Sublinear Functionals of Geometric Brownian Motion. Journal of Applied Probability, vol. 40, pp. 893-905, 2003.

P Johannesson, T Svensson, J de Maré:
Fatigue life prediction based on variable amplitude tests - methodology, presented at the international conference Cumulative Fatigue in Seville, May, 2003.

M Karlsson:
Driver independent road curve characterisation, presented at the international conference IAVSD '03 in Japan, August 2003.

G Kroisandt:
Insurance Companies; Premiums and Risk Measures, Wilmott Magazine, 2003.

K Samuelsson, A Ålund:
Elastic properties of paper in a simulation framework, FCC-Report 206-030703-144, Göteborg, July 2003.

K.Samuelsson, A.Ålund:
Theory and user manual for SimTool GUI 1.0, FCC-Report 206-030703-143, Göteborg, July 2003.

T Svensson, P Johannesson, J de Maré:
Fatigue life prediction based on variable amplitude tests - specific applications, presented at the international conference Cumulative Fatigue in Seville, May, 2003.

J Andersson (co-advised by T Svensson):
The influence of grain size variation of metal fatigue, presented at the international conference Cumulative Fatigue in Seville, May, 2003.

S Lorén(co-advised by T Svensson):
Fatigue life estimated using finite lives, Fatigue and Fracture of Engineering Materials and Structures, Vol. 26, pp. 757-766, 2003.

S Lorén (co-advised by T Svensson):
Estimating inclusion distributions of hard metal using fatigue tests, International Journal of Fatigue, Volume 25, Issue 2, February 2003, Pages 129-137

Thesis

P Hörfelt (adviser C Borell):
On the Pricing of Path-Dependent Options and Related Problems. Industrimatematik. Matematiska Vetenskaper, Chalmers tekniska högskola och Göteborgs Universitet, September 26, 2004

PhD students advisement

J S Carlson adviser of Kristina Wärmefjord, Inspection Data Feedback and Analysis, Saab Automobile AB.

A-B Strömberg co-adviser of Niclas Andréasson:
Optimization of aircraft engine maintenance (in close cooperation with Volvo Aero Corporation and supported by Nationellt flygtekniskt forskningsprogram, NFFP), Chalmers.

A-B Strömberg co-adviser of Fredrik Altenstedt:
Aspects on asset liability management via stochastic programming (supported by Nordea Liv), Chalmers, October 2003.

A-B Strömberg co-adviser of Birgit Grohe:
Propagation methods for global constraints in constraint satisfaction problems, Chalmers.

A-B Strömberg co-adviser of Roger Halldin:
Scenario trees for inflow modelling in stochastic optimisation for energy planning, within the project Optimization of power systems under uncertainty (supported by STEM, Elforsk, Sydkraft and Fortum), Lund Institute of Technology.

Masters thesis advisement

A-B Strömberg examinator of Anna Svagan:
Finding good underestimates for resources required for winter road management. Chalmers and Enera International.

A-B Strömberg examinator of Petra Hugoson:
Optimization of operations in a hydro power system. Chalmers and Sydkraft Vattenkraft AB, from September 2003.

A-B Strömberg co-adviser of Jorild Engkvist and Carl Bohman:
Optimization of parameters in WAVE.
Chalmers and Volvo Car Corporation, from October 2003.

Other assignments

J S Carlson:
Reviewer for IEEE Transactions on Robotics & Automation

J S Carlson:
Reviewer for ASME Journal of Manufacturing Engineering

J S Carlson:
Reviewer for ASME International Design Engineering Technical Conferences

J S Carlson:
Member of the reference board of Teknisk Matematik, Chalmers

PhD students Kristina Wärmefjord (advised by J Carlson and partly financed by FCC), Niclas Andréasson (co-advised by A-B Strömberg, FCC), Johan Svensson (co-advised by T Svensson, FCC), Magnus Karlsson (advised by T Svensson, FCC), and Per Hörfelt, who defended his PhD thesis on September 26, 2003 (partly financed by FCC).

FCC staff on December 19, 2003.

From left to right Johan Carlson, Sture Holm, Tomas Torstensson, Mats Jirstrand, Mats Larson, Kristina Wärmefjord, Klas Samuelsson, Marina Alexandersson, Magnus Karlsson, Elin Lidström, Fredrik Ekstedt, Malin Moberg, Thomas Svensson, Jenny Ekenberg, Robert Bohlin, Sofia Andersson, Anders Ålund, Ann-Brith Strömberg, Per Hörfelt, Michael Patriksson, Jacques de Maré, Annika Eriksson, Pär Johannesson, Gerald Kroisandt, Uno Nävert.

Annika Eriksson and Uno Nävert, editors.

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The Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC has been founded by Chalmers and Fraunhofer-Gesellschaft as a business making, non-profit Swedish foundation.

The purpose of FCC is to promote the application of mathematical methods in industry. To do so the Centre will undertake pre-competitive scientific research in the field of applied mathematics and work on projects defined by companies or public institutes.

The Centre, in close co-operation with Chalmers in Göteborg and Fraunhofer ITWM in Kaiserslautern, shall be a leading partner for international industry and academia to mathematically model, analyse, simulate, optimize, and visualize phenomena and complex systems in industry and science, to make development of products and processes more efficient and secure their technological and financial quality.