University of Jyväskylä
Department of Mathematics
Laboratory of Scientific Computing

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Raino A. E. Mäkinen (editor)

UNIVERSITY OF JYVÄSKYLÄ
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Contents

1 PREFACE

The Laboratory of Scientific Computing (LSC) at the University of Jyväskylä belongs to the Department of Mathematics. The laboratory was founded in 1992 by professor P. Neittaanmäki. The main focus of LSC has been since its beginning to organize the doctoral education and research in numerical mathematics, computer science and optimization. Since 1995 telecommunications and software engineering have been joined to the doctoral and research programme. The Institute has a staff of 52 full-time employees including 5 professors.

The staff of the Laboratory collaborate with researchers from other Finnish universities and research institutes as well as from industry. Furthermore, we have collaboratorion with several foreign universities and research institutes. We had 25 visitors in 1997 and the members of the staff gave 22 presentations abroad in conferences and colloquia.

In 1997, the researchers of the Laboratory published 17 refereed papers in journals, 23 conference and collected papers and 18 other publications (reports etc.).

Our researchers took part in 9 international research projects funded by, e.g., the European Union. Our national sponsors have been the University of Jyväskylä, the Academy of Finland, TEKES (Technology Development Centre), Valmet Corporation, VTT (Technical Research Centre of Finland) and some small enterprises as well as some research and cultural foundations.

Scientific computing is one of the four research programmes of the Jyväskylä Graduate School in Computing and Mathematical Sciences (COMAS). COMAS is a doctoral programme, jointly organized by the Department of Computer Science and Information Systems, the Department of Statistics, and the Department of Mathematics at the University of Jyväskylä. In 1997, 5 doctoral theses and one licentiate thesis have been completed.

Jyväskylä, December 1997
Raino A. E. Mäkinen

2 PERSONNEL AND VISITORS

2.1 Personnel in December 1997

The Laboratory of Scientific Computing is a part of the Department of Mathematics at the University of Jyväskylä. The personnel consists of teaching staff and researchers.

Pekka Neittaanmäki (PhD, prof. in Scientific Computing)	pn@math.jyu.fi
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Kari Lieska (research assistant)	

2.2 External Docents

Timo Eirola from the Helsinki University of Technology
Heikki Haario from the University of Helsinki
Veikko Hara from the Telecom Finland
Jaroslav Haslinger from Prague, Czech Republic
Nils G. Högnäs from Åbo Academi University
Erkki Laitinen from the University of Oulu
Corneliu A. Marinov from Bucharest, Romania
Seppo Pohjolainen from the Technical University of Tampere
Rolf Stenberg from the University of Innsbruck, Austria
Dan Tiba from Bucharest, Romania

2.3 Part-Time Foreign Professors

Prof. Yu.A. Kuznetsov from Houston, USA
Prof. J. Periaux from Paris, France

2.4 Foreign Visitors

Dr. Z. Biro from Budapest, Hungary, May 20–30
Dr. A. Bespalov from Moscow, Russia, May 12–June 1
Prof. N. Banichuk from Moscow, Russia, Apr 2–12, June 13–July 20
Prof. I.B. Erunova from St. Petersburg, Russia, October 15–December 15
Dr. I. Farago from Budapest, Hungary, June 26–July 16
Dr. S. Finogenov from Moscow, Russia, May 12–June 1
Prof. P. Gacs from Boston, U.S.A., August 3–10
Prof. M. Garzon from Memphis, U.S.A., December 7–20
Prof. J. Haslinger from Prague, Czech Republic, October 12–31

Dr. D. Hilding from Linköping, Sweden, December 6–12
Prof. R. Hoppe from Augsburg, Germany, August 3–15
Dr. P. Koiran from Lyon, France, November 3–9
Prof. M. Křiček from Prague, Czech Republic, January 20–February 9
Prof. A. Lapin from Kazan, Russia, October 20-22
Prof. A. Lotov from Moscow, Russia, October 20–21
Prof. L. Luksan from Prgague, Czech Republic, February 9–21
Prof. H. Metz from Leiden, Holland, August 6–8.
Prof. S. Nepomnyaschikh from Novosibirsk, Russia, August 10–September 7
Prof. O. Pironneau from Paris, France, November 27–29
Prof. U. Raitums from Riga, Latvia, October 6–25
Dr. J. Šima from Prague, Czech Republic, August 11–September 6
Dr. V. Sirotkin from Moscow, Russia, September 1–October 21
Dr. D. Tiba from Bucharest, Romania, October 17–December 15
Prof. J. Weibull from Stockholm, Sweden, August 7–8
Prof. M. Viczek from Budapest, May 20–30

2.5 Advisory Board of the Laboratory

The laboratory has an international advisory board. The members are
Prof. R. Ewing, from Texas A&M University, USA
Prof. K.-H. Hoffman, from Technical University of Munich, Germany
Prof. Kenmochi, from Chiba University, Japan
Prof. O. Pironneau, from Paris-6 University (Universite Pierre et Marie Curie), France
Prof. J. Sarvas, from Rolf Nevanlinna Institute, Finland

3 TEACHING ACTIVITIES AND STUDIES

3.1 Undergraduate Teaching

Lecture courses were given in 1997 on applied mathematics and computer science in three levels for undergraduate students. Topics of the courses were programming in C++ and Fortran90, foundations of theoretical computer science, applications for microcomputers, operating systems, numerical methods, optimization, genetic and neural computing with applications.

3.2 Postgraduate Teaching

3.2.1 COMAS Graduate School

Jyväskylä Graduate School in Computing and Mathematical Sciences (COMAS) was founded in 1994. COMAS is a doctoral programme in computing and mathematical sciences offered by the University of Jyväskylä. The programme is jointly organized by three departments: the Department of Computer Science and Information Systems, the Department of Statistics, and the Department of Mathematics. The director of the COMAS Graduate School is Professor Pekka Orponen.

COMAS seeks to offer scientifically world-class education on the highest level of academic studies in the fields of an increasing importance. The four COMAS doctoral programmes are: Scientific Computing, Information Systems, Statistics and Software Engineering.

The Scientific Computing programme covers all the essential steps needed in computational modelling of real life phenomena. The main research areas are mathematical modelling, discretization methods (FEM), efficient solution methods (fast solvers, domain decomposition, parallelization), optimization and optimal control, and neural computing. It is anticipated that the research related to telecommunication will have an important role in the near future. The head of the programme is professor Pekka Neittaanmäki.

The COMAS programme provides wide international research co-operation. It is already involved in about 10 projects financed by the European Union. The students study in research projects, in close contact with professors and post-doctoral researchers. The participating departments have 17 professors or associate professors. Each student has one main advisor and two other advisors (from Finland or abroad). The COMAS programme consists of about 50 full-time doctoral students.

3.2.2 The 7th International Summer Semester

The annual series of International Summer Semesters at the University of Jyväskylä provide advanced lectures for graduate students and recent post-docs in mathematics, computing, and the sciences. As part of the 1997 programme the Laboratory, in collaboration with the Mathematics department, organized five lecture courses and a graduate workshop on the theory and applications of dynamical systems theory. The lecture courses were:

- Reliable cellular automata with self-organization (P. Gacs, 10 h)
- Introduction to extended dynamical systems (T. Gallay, Paris, 10 h)
- Quasiconformal surgery in holomorphic dynamics (B. Branner, Copenhagen, 10 h)
- Adaptive Dynamics (Hans Metz, Leiden, 5h)
- Evolutionary Game Theory (Jörgen Weibull, Stockholm, 5 h)

Each of the lecture courses had an audience of ca. 30 students from several countries. Altogether the 1997 Summer Semester was attended by 297 participants and 40 teachers from 29 different countries.

3.2.3 Doctoral Students

Vladimir Akimov: Computational fluid dynamics
Teemu Antti-Poika: Complex System Models of Computation
Erkki Häkkinen: Neural Networks
Kari Kärkkäinen: Free Fluid Surfaces

Dimitri Kuzmin: Free Boundary Problems in Chemical Reactions
Mika Laitinen: Radiation Heat Transfer
Anssi Lensu: Neural Networks
Janne Mäkinen: Optimization
Reijo Pietikäinen: Modelling of Copying Behaviour of Paper
Petri Pyöriä: Neural Networks
Tuomo Räisänen: Mathematical Modelling of Multiphase Systems
Tapani Ristaniemi: Signal separation in CDMA
Kari Saarinen: Modelling and Simulation of IR-measurement of Humidity (ABB-Strömberg Inc.)
Lioudmila Seioukova: Free Boundary Problems in Chemistry
Anton Smolianski: Free Boundary Problems for reacting bubbles
Tomi Suviola: Modelling and Simulating Peat Drying
Mika Wikström: Optimization of Data Communication Networks

3.2.4 Completed Degrees

One licentiate degree and six doctor's degrees were completed in 1997.

PhLic

1. Tapani Ristaniemi: Stability Theory and Applications to Neural Network Dynamics.

PhD-theses

1. Erkki Heikkola: Domain decomposition method with nonmatching grids for acoustic scattering problems, University of Jyväskylä, Department of Mathematics, Report 76, 1997.

2. Joonas Hokkanen: Aiding public environmental decision making by multicriteria analysis University of Jyväskylä, Department of Mathematics, Report 72, 1997.

3. Sergey Korotov: Variational crimes and equilibrium finite elements in three-dimensional space, University of Jyväskylä, Department of Mathematics, Report 74, 1997.

4. Aarni Lehtinen: Asymptotic solutions for the best choice problems, University of Jyväskylä, Report 73, 1997.

5. Liping Liu: Finite element analysis of nonlinear heat conduction problems, University of Jyväskylä, Department of Mathematics, Report 75, 1997.

6. Jari Toivanen: Fictitious domain method applied to shape optimization, University of Jyväskylä, Department of Mathematics, Report 77, 1997.

4 RESEARCH PROJECTS

The research projects are organized as projects in six main research areas. In the year 1997, these areas were

- foundations of computational methods,
- mathematical modelling and computational mechanics and physics,
- control and identification,
- computational methods of large-scale systems
- systems and operations research, and
- neural networks and applications.

Within each research area, a reasonable level of synergy between different projects is generally provided either by the use of similar methods or by the study of similar problems with different types of methods.

The different research areas have a common mathematical background which makes the communication possible between projects in different areas. Moreover, much effort has been invested in a common computational environment. On the one hand, it reduces the routine work in the projects, and, on the other hand, makes it easier for the projects to communicate with each other.

4.1 Foundations of Computational Methods

Finite Element Methods and Applications (Michal Křížek, Raino A.E. Mäkinen, Pekka Neittaanmäki and Timo Tiihonen)

The project deals with the finite element analysis of some important, mostly nonlinear problems. As there is no general numerical method capable of solving an arbitrary nonlinear problem, the attention has to be restricted to concrete problems arising from important applications. Currently, the fields of active interest include problems in electromagnetics, free boundary problems and situations where finite elements are used in connection with integral equations (for example, heat radiation).

Nondifferentiable Multiobjective Optimization with Applications (Kaisa Miettinen, Marko M. Mäkelä, Janne Mäkinen and Jari Huikari)

The current aim of this project has been to develop user-friendly and numerically efficient methods for nondifferentiable multiobjective optimization. Two versions of an interactive NIMBUS method have been developed and compared. They have also been implemented in both mainframe and World-Wide Web (WWW) environments. The WWW provides a way to centralize computing and distribute interface and have graphical illustrations in the interactive algorithm. The URL is http://nimbus.math.jyu.fi/. This project has been supported by the Academy of Finland.

4.2 Computational Mechanics and Physics

Research in computational mechanics and physics is quite application oriented. All the central research topics originate from industry or from research laboratories. The most important areas are problems related to paper and papermaking, free boundary problems and heat radiation. A significant part of the research funding comes from outside the university.

Modelling and Simulation of Multi Phase Systems (Kai Hiltunen (VTT), Dmitri Kuzmin, Anton Smolianski, Tomi Suviola and Timo Tiihonen)

The research is mainly motivated by problems arising from paper and chemical industries. Modelling of pulp behavior during papermaking leads to study of particulated flows. Numerical methods are developed using the stabilized finite element method. Numerical modelling of drying of porous media is also studied.

The other main line of research focuses to bubbly flows undergoing chemical reactions. Both microscopic and macroscopic approaches are studied. In microscopic model the evolution of the chemical reaction around a single gas bubble is modelled as a time dependent free boundary problem. The macroscopic model is a volume averaged multiphase system.

Free Boundary Problems (Kari Kärkkäinen, Tuomo Räisänen, Anton Smolianski and Timo Tiihonen)

Free boundary problems form one of the main research fields of the laboratory. In the past, the work on free boundary problems and related control problems has initiated the research in nonsmooth optimization and in state constrained control problems. Currently, the laboratory takes part in the ESF programme "Mathematical Treatment of Free Boundary Problems".

The theoretical work on free boundary problems concentrates now on modelling the evaporation process. The goal is to find adequate free boundary conditions for a coupled system of Navier-Stokes and Stefan equations, as well as to develop suitable techniques for mathematical analysis and numerical solution of such problems.

Another main line in the research is the use of techniques developed for shape optimization in solving free boundary problems and analysing the solution methods. Often, free boundary conditions can be formulated as optimality conditions of a shape optimization problem. Analysis of the shape optimization problems suggests methods for efficient solution of the free boundary problems. The methods are developed for applications in naval hydrodynamics in co-operation with the Maritime Institute of Finland.

There is also work going on in numerical simulation of industrial processes involving solidification. A numerical model for production of silicon crystals has been constructed which takes into account all the major mechanisms of heat transfer including solidification and heat radiation. For simulation of the continuous casting of steel new linearization algorithms are being developed. The aim is to construct a real time simulation for 3D casting process.

Mathematical Modelling of Heat Radiation (Mika Laitinen and Timo Tiihonen)

In this project, thermodynamical models for heat radiation are analysed from the mathematical point of view. The models lead to nonlinear integro-differential equations. So far the work has concentrated on the mathematical properties of models for gray materials leading to adequate solvability theory. Also the numerical approximation has been considered from the theoretical point of view.

4.3 Control and Identification

The research of control theory has been concentrated in optimal control of nonlinear distributed systems. Emphasis has been on the development of numerical methods and the solution of real-life applications. The research of parameter identification has been concentrated in identification of the coefficients in distributed systems by using the measured data. The identification has several applications, for example, in computer tomography, geology and environmental sciences. Emphasis has been on the analysis and development of numerical methods.

Optimal Control of Nonlinear Systems (Timo Männikkö, Pekka Neittaanmäki and Tuomo Räisänen)

The purpose is to study optimal control problems, especially, systems arising from free boundary problems. The main interest has been in optimal control problems governed by nonlinear parabolic systems, including, among others, parabolic variational inequalities and systems with phase transitions. The aim is twofold: first, to give a theoretical approach to the subject and, secondly, to present detailed algorithms (with convergence proofs) that are necessary in computerizing the optimal control processes. Several practical examples are being worked out in detail in order to demonstrate the usefulness of the proposed methods.

Collaboration with researchers from France, Germany, USA, Japan and Romania.

Hemivariational Inequalities (Markku Miettinen)

In this project, hemivariational inequalities, generalized variational inequalities involving nonmonotone, multivalued inclusion, are studied. The existence results have been shown for a constrained stationary hemivariational inequality and for a parabolic hemivariational inequality. In addition, a stable and convergent FEM approximation has been developed for these equations. This approximation has been used in the numerical solutions of nonmonotone contact problems of linear elasticity by nonsmooth, nonconvex optimization methods.

Collaboration with Aristotle University, Greece (prof. P.D. Panagiotopoulos) and Charles University, Czech Republic (prof. J. Haslinger).

Parameter Identification (Pekka Neittaanmäki and Tommi Kärkkäinen)

The aim of the project is to develop methods for the identification of functional coefficients. It is assumed that one has a distributed observation of the solution of an elliptic or parabolic partial differential equation. These observations are used to determine the unknown coefficients in the equation. In physical systems, unknown parameters can represent, for example, the heat conductivity or the diffusion coefficient. The main emphasis lies on derivation and analysis of new efficient numerical algorithms.

Collaboration with Karl-Franzens-University of Graz, Austria (prof. K. Kunisch).

Material and Structural Optimization (Markku Miettinen, Tommi Kärkkäinen and Anu Hillebrand)

In this project the aim is to develop effective numerical methods for material and structural optimization by using homogenization method. Collaboration with Charles University (prof. J. Haslinger) and University of Latvia (prof. U. Raitums).

4.4 Computational Methods for Large-Scale Problems

Numerical solution algorithms for large-scale (non)linear algebraic systems and shape optimization problems are studied. Emphasis is given to efficient parallel algorithms suitable for distributed memory multiprocessor computers.

Fast Direct Methods (Erkki Heikkola, Yuri A. Kuznetsov, Tuomo Rossi and Jari Toivanen)

Parallel fast direct methods for solving linear systems with separable matrices have been considered. They have many applications, for example, in the parallelization of fictitious domain methods. Their efficiency has been verified by several numerical experiments which were carried out in Cray T3E computer. Another research topic has been the development of (approximate) partial solution techniques.

Fictitious Domain Methods (Erkki Heikkola, Yuri A. Kuznetsov, Tuomo Rossi and Jari Toivanen)

The aim has been to develop and analyze efficient numerical methods based on the fictitious domain approach for solving elliptic partial differential equations. The applications include, for example, acoustic scattering problems, (full) pontential flows and the related shape optimization problems. Special emphasis has been given to new research areas such as the use of Lagrange multipliers and nonmatching discretization meshes.

Iterative Methods for Obstacle Problems (Tommi Kärkkäinen and Pasi Tarvainen)

Numerical solution of unilateral and bilateral variational inequalities (obstacle problems) has been considered. Based on finite difference or finite element discretization, various iterative methods, like active set strategies and Schwarz domain decomposition methods, have been proposed for the resulting algebraic systems. Special emphasis has been given to algorithms approximating the characteristic domain decomposition of the obstacle problem into active and inactive subdomains. Such an approach gives an opportunity to apply fast linear system solvers to genuinely nonlinear obstacle problems. Theoretical results as well as efficient implementation procedures have been developed.

Collaboration with Karl-Franzens-University of Graz, Austria (prof. K. Kunisch).

Parallel Algorithms Based on Schwarz Methods for Singularly Perturbed Problems (Pasi Tarvainen)

Domain decomposition algorithms based on the Schwarz alternating method are developed for the numerical solution of singularly perturbed elliptic and parabolic problems. The emphasis is given to their parallel computer realization on distributed memory multiprocessor computers as well as investigation of their behaviour with respect to the "critical" parameters, such as the perturbation parameter, the overlapping size, and the number of parallel processors.

Collaboration with Dr. V. Sirotkin from the Institute of Microelectronics and High Purity Materials, Russian Academy of Sciences.

Numerical Methods for Shape Optimization (Pekka Neittaanmäki, Raino A.E. Mäkinen, Pasi Tarvainen and Jari Toivanen)

Efficient and robust methods for multidisciplinary shape optimization problems governed by state equations modelling problems in computational fluid dynamics and electromagnetics have been studied and developed. Typically, two-dimensional state equations are described by the (full) potential flow, Navier-Stokes and the time-harmonic Helmholtz equations. The shape optimization problem is formulated as a nonlinear minimization problem. Each objective function evaluation requires one solution of a state equation, which can be obtained by using a fictitious domain method or a multigrid method, for example. In the minimization of the objective function, parallel implementations of genetic algorithms and gradient-based methods such as SQP have been employed.

Interactive Graphical Energy Modelling and Optimization (Petri Ebeling, Henri Hakonen, Risto Lahdelma, Heikki Liimatainen, Simo Makkonen, Markku Ollila and Juha Sankola)

Successful trade in the newly deregulated European electricity market requires that energy companies simultaneously maximize their net profits while maintaining an optimal portfolio of energy sales and purchase contracts. In the EHTO-project we are developing a PC-based energy modelling and optimization system which allows the user to configure and parametrize the model graphically using object-oriented model components for multi-tariff contracts, thermal and hydro power plants, cogeneration facilities and the spot market. Optimization of energy acquisition, tariff components of contracts and unit commitment result in various large optimization problems (about 1.000.000 variables) which are solved efficiently using special decomposition techniques.

The research is funded, in part, by the Technology Development Centre Finland, and it is conducted in cooperation with Helsinki University of Technology and Process Vision Ltd. Among end users are the energy companies Jyväskylän Energia Ltd, Keski-Suomen Valo Ltd, Savon Voima Ltd, Forssan Energia Ltd and the Kymppivoima Ltd power pool.

Multicriteria Decision Support in Environmental Problems (Sami El-Mahgary, Henri Hakonen, Joonas Hokkanen, Risto Lahdelma, Kaisa Miettinen and Pekka Salminen)

The project develops multicriteria group decision support methods and software for real-life public decision processes in environmental problems. Stochastic Multiobjective Acceptability Analysis (SMAA) is a new inverse method based on stochastic simulation for exploring the preferences resulting in a given decision. The research is funded, in part, by the Academy of Finland and the Technology Development Centre of Finland, and it is conducted in cooperation with Helsinki University of Technology and Paavo Ristola Consulting Engineers Ltd.

Among the applications have been solid waste management systems (SWMSs) for Uusimaa, Jämsä, Joutsa, Kokkola, the Kalajoki Valley, Oulu and Savonlinna, the development of Helsinki General Cargo Harbour, general plans of the municipalities of Nastola and Kirkkonummi, and restriction of the use of chemicals in the European Union. The SMWS applications handle about 80% of all the solid waste in Finland.

4.5 Neural Networks and Applications

Research in neural networks concerns the complexity of learning and computation in neural networks, theory of self-organisation, and embedded neural network tools for data analysis. There are a large number of applications in science, commerce, and industry. Special algorithms are studied for fast and robust self-organizing maps. Software development is made for data analysis.

Complex Systems and Their Interdisciplinary Application in Science (Pekka Orponen and Teemu Antti-Poika)

The interest in complex systems, that is, systems consisting of large numbers of simple components with nonlinear interactions, has been increasing rapidly in recent years because of advances in the theory of nonlinear dynamics, the growth of computer simulation power, and the realization of the ubiquity of such systems in natural and social settings. This project brings together into close collaboration leading research groups in this area from mathematics, physics, ecology, economics, and computer science.

Computationally Intelligent Analysis of Large Data Sets (Pasi Koikkalainen, Erkki Häkkinen, Mika Rekkilä and Mohamed Tsaalby)

This topic is studied in four separate research projects, funded by the Technology Development Centre (TEKES), Jyväskylä Science Park Ltd., and private enterprises. Problems that usually involve large and complex real world data sets are analyzed using novel technology that is based on neural networks and fuzzy sets, statistics and interactive visualization techniques. The methods are implemented under a software kernel, called NDA (Neural Data Analysis) that is designed to be embedded in applications.

Several applications specific products are being developed using the kernel. These include customer profiling, industrial process monitoring, fault diagnostics, for example. A part of the work is co-operation with the University of Kuopio.

Computationally Intelligent Methods for Qualitative Data Analysis (Pasi Koikkalainen and Anssi Lensu)

The aim of this study is to develop computational methods that are widely applicable in human, economic and engineering sciences. We are aspiring after tools for qualitative data analysis to draw valid meaning from both conceptual and exact data. The concrete example is to make a computer aided system to study human learning in technology rich environments, and the methodology is based on a specific neural network model.

We match our methods with a typical problem setting in human sciences, including both cognitive empirical data and structured knowledge of the problem. Data, which are often something else than numbers, are provided by collaborating teams doing research on human learning.

Neural Networks in Telecommunication Planning (Alexandru Murgu)

The aim of the project is to adapt some basic deterministic and stochastic methods of dynamic programming onto neural networks (feedback-recurrent and feedforward). The actual goal is to get a powerful tool for handling large-scale optimization problems arising from telecommunication planning. The main topics have been sequential decision processes (like Markov decision problems and other approaches which can be finally set as Markovian decision problems) with a special emphasis on telecommunication network flow control and routing. The theory of diffusion processes and Brownian control are used to be able to describe more accurately the stochastic nature of the arrival and flow processes of the customers in small and medium sized communication networks. The intention is to construct a soft computing tool for planning.

Collaboration with the Telecommunication Laboratory of the Technical Research Centre of Finland, Telecom Finland and Nokia.

4.6 Telecommunications

Signal Processing for Code Division Multiple Access (Jyrki Joutsensalo)

CDMA (Code Division Multiple Access) is based on spread spectrum signals, and it is considered as a promising solution for wideband mobile communications. In CDMA all users are using the same frequency band at all times. In CDMA, the separation of users is carried out by assigning each user with a unique code sequence. The problem in the mobile phone (i.e. downlink) communications is that the downlink knows only its own code, while the codes of the interfering users are unknown. Moreover, it has been shown that under rather mild conditions, the data have the subspace model, and the mixing matrix is determined by the (roughly) unknown codes. More precisely, it turns out that when a mobile phone receives data from several users, and when the phone moves sufficiently slowly, the ICA (Independent Component Analysis) model arises: (i) the superposition model is linear; (ii) the codes are unknown, and so are the mixture coefficients, too; (iii) the symbols of different users are independent. In the research project it has been demonstrated how ICA techniques can be applied in downlink symbol separation. The algorithms expoiting the finite alphabet property of the symbols have been developed. It has also been developed nonlinear neural and competitive approaches such as Generative Topographic Mapping in oversaturated systems, i.e. when there are more users and paths than the mixtures.

4.7 Computational Environment

Computer Facilities

The Laboratory of Scientific Computing and the Department of Mathematics had 8 processor Sun Ultra Enterprise 4000 server, 30 HP-9000 series workstations and X-terminals, 3 Sun Ultra Workstations, 40 Pentium-level and 20 486-level PCs and one Silicon Graphics Indigo2 for researchers and students in 1997. In addition, the facilities at the Finnish National Supercomputer Centre (Cray T3E) and the Computer Centre of the University of Jyväskylä (VAX 4000-300 and four SUN 4/670 computers connected to terminals and PCs with a local area network) were available.

Software development has a major role in many projects. In this respect, many projects have shared interests and needs. This has led to the development of program libraries common to the whole laboratory.

FEMPAK (Raino A.E. Mäkinen and Jari Toivanen)

FEMPAK 1.0 is a portable software package for the numerical solution of two-dimensional partial differential equations. It is based on the finite element method. The package consists of a set of low-level subroutines for the assembly and solution of the discrete finite element equations, a set of example driver programs and software to visualize the results. The graphical devices supported are X-windows and PostScript.

NDA (Erkki Häkkinen and Pasi Koikkalainen)

The Neural Data Analysis (NDA) is an environment for data modeling, data reduction, and visualization. It has special support for neural network algorithms, like the tree structured self-organizing map. Most of the functionality is in the kernel, which is portable end easy to interface with other software. Example interfaces are provided via postscript, Xview, Visual Basic, and Java. NDA based products, made by private enterprices, include customer profiling, fault diagnostics and process modeling.

NDA software has been developed under TEKES technology programme on "Adaptive and Intelligent Systems Applications".

NSOLIB (Marko M. Mäkelä)

NSOLIB is a Fortran subroutine library for nonsmooth and nonconvex optimization problems with single or multiple objective functions. The methods are able to handle either simple bounds for variables, linear, nonlinear or nonsmooth constraints, or all of them at the same time. NSOLIB subroutines are implementations of the proximal bundle method. They have been tested with various standard test examples and in several research projects of the laboratory in different computing environments (microcomputers, workstations, mainframe and supercomputers). There is a need for NSOLIB since commercial subroutine packages do not contain efficient codes for nonsmooth optimization.

WWW-NIMBUS (Kaisa Miettinen, Marko M. Mäkelä, jari Huikari and Janne Mäkinen)

WWW-Nimbus is an implemetation of NIMBUS (Nondifferentiable Interactive Multiobjective BUndlebased optimization System). It works via the Internet being available to everyone. The calculation has been centralized into a server computer at the Laboratory and the WWW provides a graphical user interface.

5 EXTERNAL FINANCING

The main sources of external financing during the year 1997 have been the following ($\times$ 1000 FIM).

- Academy of Finland, about 2.200
- Technology Development Centre of Finland (TEKES), about 830
- COMAS Graduate School, about 800
- Other External Sources (industry, research institutions, EU), about 2030

6 NATIONAL AND INTERNATIONAL COOPERATION

6.1 National cooperation

In Finland, the Laboratory of Scientific computing has made cooperation with

- Tampere University of Technology,
- Lappeenranta University of Technology and
- Helsinki University of Technology

6.2 International research programs

The laboratory has taken part in the following international research programs:

- DECISION-project: DECISION (Integrated Optimization Strategies for Increase Engineering Design Complexity) is a EU Esprit project with seven academic and industrial partners from France, Great Britain and Finland, period 1997–2000.
- ESF (European Scientific Foundation) programme: Mathematical Treatment of Free Boundary Problems, period 1993–1997, 18 countries from Europe, more than 25 research groups and programme contains about fifty students.
- HCM (Human Capital and Mobility) programme: Control Problems and Applications, period 1994–1997, network of eight research groups.

- INTAS (International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union) program: Mathematical and numerical modelling of phase changing problems. The universities involved are University of Jyväskylä, St. Petersburg Technical University, Technical University of Munich and University of Milan, period 1995–1998.

- INGENET (Networked industrial design and control applications using genetic algorithms an evolution strategies): Thematic Network with 21 academic and industrial partners from eight European countries.

- ERASMUS (Mathematics and Fundamental Applications)

- Research Exchange Programs
  - Macro-hybrid Finite Element Methods Based on Domain Decomposition with Applications to Fluid Dynamics and Electromagnetics (The Exchange program of the Academy of Finland and the Russian Academy of Science).
  - Numerical Methods for Fluid Flow Simulation (Exchange program between the Laboratory of Scientific Computing and the Department of Mathematics and Mechanics, University of St. Petersburg).
  - NorFA Network on Structural Optimization (Exchange program between Finland, Sweden, Denmark, Estonia and Latvia).

7 PARTICIPATION IN CONFERENCES AND VISITS TO FOREIGN INSTITUTIONS

7.1 Talks in Conferences

Erkki Heikkola gave a talk in

- IMPC 97 conference, Milovy, Czech Republic, June 13–18.

- ENUMATH 97 conference, Heidelberg, Germany, September 29–October 3.

Pasi Koikkalainen gave talks in

- SCIA'97 conference, Lappeenranta, Finland, June 9–11.

- ARV'97 PhD summerschool, Copenhagen, Denmark, August 20–25.

Marko M. Mäkelä gave a talk in

- 16th International Symposium on Mathematical Programming, Lausanne, Switzerland, August 24–29.

Raino A.E. Mäkinen gave a talk in

- NorFA Network on Structural Optimization, Workshop, Skörping, Denmark, May 2–4.

Kaisa Miettinen gave talks in

- 13th International Conference on Multiple Criteria Decision Making, Cape Town, South Africa, January 6–10.
- 16th International Symposium on Mathematical Programming, Lausanne, Switzerland, August 24–29.
- APORS'97, The Fourth Conference of the Association of Asian-Pacific Operational Research Societies within IFORS, Melbourne, Australia, November 30 – December 4.

Markku Miettinen gave talks in

- Second SIAM conference on Mathematical Aspects of Material Science, Philadelphia, USA, May 12–14.
- Equadiff 9 conference, Brno, Czech Republic, August 25–29.

Pekka Neittaanmäki gave talks in

- Computational Science for the 21st century conference, Tours, France, May 5–7.

Pekka Orponen gave talks in

- AMS Southeastern Section Meeting, Memphis, U.S.A., March 21–22.
- Workshop on Algorithms, Languages and Complexity in Honor of prof. R.V. Book, Minneapolis, U.S.A., April 12.
- SOFSEM'97, Milovy, Czech Republic, November 22–29.

Tuomo Rossi gave a talk in

- Euro–par'97 conference, Passau, Germany, August 26-29.

Pasi Tarvainen gave a talk in

- IMPC'97 conference, Milovy, Czech Republic, June 13–18.

Timo Tiihonen gave talks in

- 8th Intnl Colloq. on Differential equations, Plovdiv, Bulgaria, August 18–23.
- Nordic graduate student workshop in computational science and engineering, Linköping, Sweden, September 29–October 1.

Jari Toivanen gave talks in

- Eighth SIAM conference on Parallel Processing for Scientific Computing, Minneapolis, MN, USA, March 14-17.
- IMPC'97 conference, Milovy, Czech Republic, June 13-18.
- ENUMATH 97 conference, Heidelberg, Germany, September 29-October 3.

7.2 Research Visits to Foreign Institutes

Erkki Heikkola

- University of Houston, Houston, Texas, February 5–April 27.
- Russian Academy of Sciences, Moscow, Russia, August.
- University of Augsburg, Augsburg, Germany, October.

Pasi Koikkalainen

- Pechlney Corporate Research Centre, Grenoble, France, March.

Tommi Kärkkäinen

- Karl-Franzens University of Graz, Austria, October 5–24.

Mika Laitinen

- ITWM, Kaiserslautern, Germany, Oct 9–10.

Markku Miettinen

- Aristotle University, Thessaloniki, Greece, January 1–April 30.
- Charles University, Prague, Czech Republic, September 1–6.

Pekka Neittaanmäki

- Dassault Aviation, Paris, France October 13–14.
- Technical University of Berlin, Berlin, Germany, October 31–November 2.

Pekka Orponen

- Edinburgh University, U.K., January 1–February 23, April 26–June 22.
- Boston University, U.S.A., February 24–April 25.

Tuomo Rossi

- INRIA Rocquencourt, Le Chesnay, France, March 3-July 25.
- Russian Academy of Sciences, Moscow, Russia, August 4-7.

Pasi Tarvainen

- Eötvös Loránd University, Budapest, Hungary, October 27–November 2.

Jari Toivanen

- University of Houston, Houston, TX, USA, March 19–20.
- Russian Academy of Sciences, Moscow, Russia, August 4–7.
- University of Augsburg, Augsburg, Germany, October 6–7.

8 PUBLICATIONS

8.1 Journal Papers

1. J. Haslinger and R.A.E. Mäkinen, Shape optimization of materially non-linear bodies in contact, Appl. Math., vol. 42 (1997), 171–193.

2. K. Hiltunen, A Stabilized finite element method for particulate two-phase flow equations Laminar isothermal flow, Comput. Methods Appl. Mech. Engrg., vol. 147 (1997), 387–399.

3. J. Järvinen, R. Nieminen and T. Tiihonen, Time-Dependent Simulation of Czochralski Silicon Crystal Growth, Journal of Crystal Growth, vol. 180 (1997), 468–476.

4. J. Karhunen, E. Oja, L. Wang, R. Vigario and J. Joutsensalo, A Class of Neural Networks for Independent Component Analysis, IEEE Transactions on Neural Networks, vol. 8 (1997), 486–504.

5. T. Kärkkäinen, Estimates of the rate of convergence for distributed parameter identification in linear parabolic problems, Journal of Mathematical Systems, Estimation, and Control, vol. 7 (1997), 231–234.

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9. T. Kärkkäinen, An equation error method to recover diffusion from the distributed observation, Inverse Problems, vol. 13 (1997), 1033-1051.

10. M. Laitinen and T. Tiihonen, Heat transfer in conducting and radiating bodies, Applied Mathematics Letters, vol. 10:5 (1997), 5–8.

11. M. Miettinen and J. Haslinger, Finite element approximation of vector-valued hemivariational problems, Journal of Global Optimization, vol. 10 (1997), 17–35.

12. P. Orponen, Computing with truly asynchronous threshold logic networks, Theoretical Computer Science, vol. 174 (1997), 97–121.

13. P. Orponen, Mathematics and Computer Science (in finnish), Arkhimedes, vol. 2, 1997, 25–29.

14. P. Tarvainen, Numerical algorithms based on characteristic domain decomposition for obstacle problems, Communications in Numerical Methods in Engineering, vol. 13 (1997), 793–801.

15. T. Tiihonen, Stefan-Boltzmann radiation on non-convex surfaces, Mathematical methods in the Applied Sciences, vol. 20 (1997), 47-57.

16. T. Tiihonen, A nonlocal problem arising from heat radiation on non-convex surfaces, European Journal of Applied Mathematics, vol. 8 (1997), 403–416.

17. T. Tiihonen, Shape optimization and trial methods for free boundary problems, Mathematical Modelling and Numerical Analysis, vol 31 (1997), 805–825.

8.2 Conference and Collected Papers

1. E. Häkkinen and P. Koikkalainen, The Neural Data Analysis environment, Proceedings of WSOM'97, Workshop on Self-Organizing Maps, Helsinki University of Technology, Neural Networks Research Centre, 1997, 69-74.

2. E. Häkkinen and P. Koikkalainen, SOM based visualization in data analysis, Proceedings of ICANN'97, 7th International Conference on Artificial Neural Networks, W. Gerstner, A. Germond, M. Hasler and J.-D. Nicoud (Eds.), Springer-Verlag, 1997, 601–606.

3. T. Hämäläinen and I. Defee, Performance test of 622MG/S ATM links in local area network, Proceedings of FINSIG'97 Conference, Pori, 1997.

4. J. Joutsensalo, J. Lilleberg, A. Hottinen and J. Karhunen, Subspace Algorithms for Synchronization and Tracking in CDMA, Signal Processing Advances in Wireless Communications, M. Viberg and J.-F. Cardoso (Eds.), IEEE, 1997, 369–372.

5. Yu.A. Kuznetsov, P. Neittaanmäki and P. Tarvainen, Overlapping block methods for obstacle problems with convection-diffusion operators, Complementarity and Variational Problems: State of the Art, M. Ferris, J.-S. Pang (eds.), SIAM, Philadelphia, 1997, 165–180.

6. T. Rossi and J. Toivanen, A Parallel Fast Direct Solver for the Discrete Solution of Separable Elliptic Equations, Proceedings of the Eighth SIAM Conference on Parallel Processing for Scientific Computing, SIAM, Philadelphia, 1997 (CD-ROM).

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8. J. Joutsensalo, Algorithms for Delay Estimation and Tracking in CDMA, Proceedings of IEEE International Conference on Communications, 1997, 366–370.

9. P. Luukkanen and J. Joutsensalo, Comparison of MUSIC and Matched Filter Delay Estimators in DS-CDMA, Proceedings of IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications, IEEE Communications Society, 1997, 830–834.

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14. K. Miettinen and M. M. Mäkelä, Interactive Method NIMBUS for Nondifferentiable Multiobjective Optimization Problems, Multicriteria Analysis. Proceedings of the XIth International Conference on Multiple Criteria Decision Making, J. Climaco (ed.), Springer-Verlag, 1997, 310–319.

15. M. M. Mäkelä and K. Miettinen, Comparison of Some Nondifferentiable Multiobjective Optimization Methods, Proceedings of the Second Noon2nooN Seminar on Decision Science and Applications, K. Miettinen (ed.), University of Jyväskylä, Department of Mathematics, Laboratory of Scientific Computing, Report 5/1997, 17–27.

16. K. Miettinen, WWW-NIMBUS, INFORS - Suomen Operaatiotutkimusseuran jäsenlehti, vol. 1, 1997, 15–16.

17. R. A. E. Mäkinen, P. Neittaanmäki, J. Periaux, M. Sefrioui and J. Toivanen, Parallel genetic solution for multiobjective MDO, Parallel Computational Fluid Dynamics, P. Schiano, A. Ecer, J. Periaux, N.Satofuka (Eds.), North-Holland, 1997, 352–359.

18. W. Maass and P. Orponen, On the effect of analog noise in discrete-time analog computations, Advances in Neural Information Processing Systems 9, M. C. Mozer, M. I. Jordan and T. Petsche (Eds.), The MIT Press, 1997, 218–224.

19. P. Orponen, A survey of continuous-time computation theory, Advances in Algorithms, Languages, and Complexity, D.-Z. Du, K.-I Ko (Eds.), Kluwer Academic Publishers, 1997, 209–224.

20. P. Orponen, On the computational power of continuous time neural networks, Proceedings of SOFSEM'97: 24th Seminar on Current Trends in Theory and Practice of Informatics, F. Plasil, K. G. Jeffery (eds.), Springer-Verlag, 1997, 86–103.

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8.3 Reports etc.

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5. Proceedings of the Second Noon2nooN Seminar on Decision Science and Applications, K. Miettinen (ed.), University of Jyväskylä, Department of Mathematics, Laboratory of Scientific Computing, Report 5/1997.

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9. M. Miettinen and P. D. Panagiotopoulos, On parabolic hemivariational inequalities and applications, Preprint (to appear in Nonlinear Analysis).

10. R. A. E. Mäkinen, Numerical Methods (2nd ed) (in finnish), University of Jyväskylä, Dept. of Math., Lecture Notes 12, 1997.

11. T. Männikkö, Control Theory (in finnish), University of Jyväskylä, Dept. of Math., Lecture Notes 40, 1997.

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18. Proceedings of the ninth ECMI Modelling Week, T. Tiihonen (Ed.), University of Jyväskylä, Department of Mathematics, Laboratory of Scientific Computing, Report 6/1997.