First I would like to take this opportunity to thank the past president, Dr. Hilary Ockendon from Oxford, for the job she did as President of ECMI. Always with style and respect for other people’s opinion, she has successfully led ECMI during the last period. It is with humility I take over the presidency.

As I write this letter, the ECMI Council has just finished its first meeting this year. Looking around the table, I saw many young faces, which shows that ECMI has managed the transition from the “founding fathers” to a new generation. I have been part of ECMI for a long period, first serving in the Educational Committee, and later on serving in the Council. It has been an interesting development to take part in, with many heated discussions and strong opinions exchanged, but for all participants a common goal — to promote the ideas of ECMI.

So what are the fundamental ideas of ECMI? There are many different formulations and no “certified answer,” but one could formulate them as follows

- to develop a curriculum for mathematicians that are going to work in industry,
- to show industry that mathematics can contribute and that mathematics actually makes a difference in solving industrial problems, and
- to show that industrial problems can also yield interesting mathematical problems.

I remember long discussions within my department here in Trondheim about the content of the proper program in industrial mathematics. Our situation was not uncommon — to establish a program in industrial mathematics for engineering students coming to what was then called the Norwegian Institute of Technology to study physics. Many of them were highly talented, and became more interested in mathematics. Prior to our program in industrial mathematics there was no special offer for them. It is due to the efforts of several people, in particular the late Prof. Henrik Martens, one of the founding fathers of ECMI and a former President of ECMI, that such a program was established. It has turned out to be highly successful and is still based on the original ideas of ECMI, annually graduating between 30 and 40 engineers (equiv. MSc) in industrial mathematics. The discussions on how to improve the program continue, but it is commonly accepted that industrial mathematicians should have a different training to prepare them for work in industry. And the story is similar across Europe — the ideas of ECMI have turned out to be highly successful. Once controversial, one can now see the ideas of ECMI developed at many universities all over the world. Programs in industrial/applied mathematics or computational science and engineering (CSE) share many of the fundamental ideas of ECMI. There are many reasons for this development, but central is the dramatic increase in the use of computer simulation over a wide range of industries. Simulation is now used as a central tool in the decision process. Mathematical models are becoming more and more complicated, and computer simulation is used to analyze processes where experiments in laboratories dominated before. Fortunately, the success of computer simulation is not merely a question of faster hardware. The analysis and complexity of the mathematical model and development of efficient numerical techniques are at least as important to get reliable answers. Twenty years ago mathematicians with a MSc degree would either continue to work in academia, or become teachers. As a consequence of the increased use of computer simulation, industry and research institutes are now hiring the majority of graduates in mathematics. However, here mathematicians face tough competition with physicists and engineers, and this is where industrial mathematicians have to prove they make a difference. The word “industry” may no longer be appropriate; industrial mathematicians work in areas quite far from traditional “industry.” In Germany one uses the word “Technomathematik.” Various spin-offs have also been established as a result of ECMI related activities — the Institut für Techno- und Wirtschaftsmathematik in Kaiserslautern, The Johann Radon Institute for Computational and Applied Mathematics in Linz, SINTEF Applied Mathematics in Trondheim and Oslo (now re-organized in SINTEF Information and Communications Technology), and the Smith Institute for Industrial Mathematics and System Engineering in Oxford are all research institutes with strong component of industrial mathematics.

Even if our ideas are now accepted many places, one cannot say that ECMI itself has enjoyed a comparable development. It is still a small organization with institutional rather than personal membership. It has been agreed not to try to turn ECMI into a “European SIAM.” There is already the European Mathematical Society with a special committee for applied mathematics. Furthermore, several European countries have national or-
ganizations with related aims.
Among the accomplishments of ECMI we mention

- The annual modeling week has been very successful.
- ECMI has received a TMR research grant from the EU.
- ECMI together with ECCOMAS are responsible for the MACSINET project with the aim to stimulate interaction between academia and industry.
- Study groups with industry have proved to be an excellent idea.
- ECMI hosts bi-annual international conferences in industrial mathematics.

We also face several challenges. Here I mention the following:

- Little impact in certain countries, e.g., France.
- Few industrial members.
- Support from the EU.
- Our educational program.

Let me be more specific. We have several “white spots” on our map of Europe. We should strive for more influence in France. The expansion of the EU to the East opens up new possibilities. Many universities in Central and Eastern Europe want to revitalize their mathematics programs in the direction of industrial mathematics, and here ECMI can provide insight and experience to make the transition successful, even if we cannot contribute financially.

To attract industrial members has turned out to be more difficult than we anticipated. We have clearly not been able to provide services considered important by industry. New and affordable ideas on how we can make ourselves interesting to industry have turned out to be quite difficult to find.

The EU should provide our main source of support. The trans-European nature of ECMI and the promotion of ideas that are now politically accepted across Europe should make us ideally suited for support. However, there is fierce competition for funds from the EU, and no one can be certain of support. Recently we submitted an application to a program where previous related programs have enjoyed a success rate of less than 5%, and this should make one sober about our chances of actually obtaining financial support. We constantly have to monitor the development of the research programs of the EU to see where we can and should fit in.

Our educational program, which has been very successful, cannot be static. New developments will also have effects on the content of our program. Originally, our program, now denoted “technomathematics”, was strongly based on models that were given by differential equations, and with a course in mathematical modeling as a cornerstone. Such models will continue to be vital for industrial mathematics. However, during the last decade we have seen a considerable increase in discrete models. In ECMI parlance we call the two programs “technomathematics” and “economath”. I cannot refrain from saying that I do not find the name “economath” completely satisfactory — it is not really descriptive — a background in “economath” can be highly useful in technology, but has little to do with economics.

ECMI issues a certificate to students who successfully complete the ECMI program. The requirements are:

- Exchange abroad, normally 6 months with an ECMI institution or an industrial placement
- Participation in the ECMI modeling week
- To write a Master’s thesis in industrial mathematics (to be reviewed by referees).

We do think that number of certificates awarded annually is less than the number of students satisfying the criteria. Please make sure that your students receive the ECMI certificate if they satisfy the criteria. The Bologna agreement should make student exchange easier, and the projects in an applied environment are very much welcomed politically these days. When we discuss the future of ECMI we should keep in mind that our ideas are more accepted and popular than ever, and we should try to take advantage of this fact.

My last comments concern the Newsletter. Recently we introduced the idea of a Guest Editor for our Newsletter. I think this will revitalize our Newsletter. If you want to become a Guest Editor, please contact the Editor of the Newsletter. Don’t be shy!

The main ECMI event this year is our bi-annual conference, ECMI 2004 which will take place in Eindhoven, The Netherlands during 21–25 June. I am convinced that it will be an excellent conference with the right blend of academia and industry. I hope to see many of you there.

Trondheim, March 30, 2004
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Introduction

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Microelectronics is a core technology for numerous industrial innovations. Progress in microelectronics is highlighted by milestones in chip technology, i.e., microprocessor and memory chips. This ongoing increase in performance and memory density — accompanied with decreasing prices — has been made possible by computer simulation techniques and its mathematics behind, extensively used in the simulation chain process simulation — device simulation — electric circuit simulation.

- The process simulation treats the local manufacturing steps of integrated circuits. Etching, implanting or oxidation are typical simulation tasks. The mathematical problem leads to free boundary value problems for systems of partial differential equations.

- In device simulation the characteristics of semiconductor devices are computed. Drift-diffusion equations or more refined models are the mathematical base, leading to mixed parabolic-elliptic or hyperbolic initial boundary value problems.

- Circuit simulation tools must be able to simulate circuits or critical paths up to millions of basic elements like transistors, capacitors and resistors. The mathematical model leads to differential-algebraic equations.

In the simulation chain, the circuit simulation packages use the transistor characteristics derived from device simulation via table models. The dotation profiles, which are typical results of process simulation, define the input of device simulation. Changes in the manufacturing process can be used for the electric circuits performance.

References


ECMI activities

The present success of numerical circuit simulation rests on interdisciplinary cooperations of numerical analysts, computer scientists, physical-modeling experts, and electrical engineers in academe and industry. In this respect, ECMI and its members contribute to this task by the following activities.

ECMI Special Interest Group on Scientific Computing in Electronic Industry — ECMI SIG on SCEI

This group has been founded in 1997 as part of ECMI’s endeavor to strengthen the ties between applied mathematics and its industrial applications. The mathematical modeling and numerical simulation of problems arising in electrical engineering, not only in microelectronics, is both a key technology in industrial design and a rich source of various challenging problems in applied mathematics and numerical analysis.

Up to now, the SIG has focused on organizing various minisymposia at ICIAM and all ECMI biannual conferences since 1998. It was significantly involved in founding the SCEE conference series and creating MACSI-net working groups 2 and 13 (see below). For a detailed activity report, please refer to ECMI newsletter 29.

SCEE conferences

The biennial international workshops on Scientific Computing in Electronic Engineering are coorganized by ECMI SIG on SCEI and serve as a main basis to meet, discuss and stimulate research with a focus on computational electrodynamics, circuit design and coupled problems. Here we can already use the experience of four preceding conferences of the SCEE series in Darmstadt (1997), Berlin (1998), Warnemünde (2000) and Eindhoven (2002). The peer reviewed proceedings are published by Springer-Verlag Berlin.

The next conference will take place on September, 5–9 at Capo d’Orlando in Sicily. More information can be found under

http://www.dmi.unict.it/~anile/scee2004/home.html

Besides the the three columns of the preceding SCEE conferences — electromagnetism, circuit simulation and coupled problems — generic mathematical and computational methods are added as a fourth one.

MACSI-net working groups 2 and 13

From a thematic and an application-oriented side, resp., MACSI-net working group 2 on coupled problems/model reduction and 13 on electrodynamics in telecommunication are linked to mathematics in microelectronics. ECMI members are actively involved in both working groups. For example, several joint workshops of both working groups have been organized by members of ECMI SIG on SCEI. To mention but a few: Reduced order modeling and coupled problems in telecommunication (Zürich, May 2–3 2003, organized by R. Hiptmair); Optimization and coupled problems in electrodynamics (Naples, September 22–23 2003, organized by G. Ali); Coupled problems and model reduction (Wuppertal, February 19–20 2004, organized by M. Günther). In these days MACSI-net’s funding will expire. It is quite natural that the impulses and expertise of both working groups will migrate to its most active part: the ECMI Special Interst Group on Scientific Computing in Electronic Industry.

Research

On a national level, joint research projects are quite successful that link academia and industry to work on mathematics for microelectronics industry. One example is given in the contribution of Janne Roos et al. on the ARFSIM project in Finland. Another example can be found in Germany: in 2000 the German Federal Ministry of Education and Research (BMBF) has launched a three-years mathematics programme for New mathematical methods in industry and services. Within this programme, a joint project on Numerical simulation of electrical circuits in the time domain, with Infineon Technologies at Munich acting as an industrial partner and colleagues from Humboldt-University of Berlin, Johannes-Gutenberg University of Mainz, Munich University of Technology and University of Wuppertal on the academic side, had been supported with a total sum of approximately EUR 600.000,–. The following two case examples are taken from this joint project.

In telecommunications, the permanent miniaturization of devices and steadily increasing frequencies in radio-frequency applications mark the transition from micro to nano electronics. In this case, the links of the simulation chain are strongly connected in modeling and simulation: thermal evolution within a chip, distributed nature of semiconductor devices and transmission lines are to be coupled with electric effects, resulting in mixed systems of partial differential and differential-algebraic equations. To incorporate
noise effects in semiconductor devices, noise sources are to be added to the network, shifting the network equations to stochastic differential-algebraic equations. A new joint project on Numerical simulation of multi scale models for radio-frequency circuits in the time domain is devoted to these problems. Starting April this year, this project will be funded within the new BMBF mathematics programme Mathematics for innovations in industry and services.

As a next step, these encouraging results are to be lifted onto an European level. Based on the network of various contacts created within the ECMI SIG on SCEI, using the expertise and industry contacts offered by the relevant MACSI-net working groups, joint EU-projects devoted to mathematics for microelectronics industry should be accomplishable. For this task, the integration of all major European microelectronics companies is a prerequisite (see the subsequent contributions of Infineon Technologies and Royal Philips Laboratories).

Case examples

Thermal effects in SOI circuits

Over the past years, self-heating of integrated circuits has increased tremendously. This is caused by the general trend towards higher packaged density and larger number of devices. Thus industry expects power densities of about 100 Watt/cm², soon. Especially, for the recent silicon-on-insulator (SOI) transistors, this effect is technologically aggravated. To improve the switching behavior, these devices are produced with an additional dielectric layer, which separates the body and the substrate. A side effect of this dielectric oxide layer is the thermal insolation for the bottom side.

To account for heat effects, the standard in circuit simulation is to provide a thermal network model established by analogy. This model is capable of describing the cooling to environment, but neglects all thermal interaction. In this way, large circuits can be mastered. The integration of the mere local thermal evolution dates back to the seventies. Now in chip design, a detailed resolution of the temperature distribution is not feasible, but the decrease in distance demands thermal intercoupling. A synthesis can be found in applying heat conduction to primal heat-transport areas, only. Such (mainly one-dimensional) structures can be found on an SOI-chip. The inclusion of these heat effects defines a multiphysical thermal-electric problem.

The basis for a successful modeling of this mixed system is the introduction of an accompanying thermal network (AN). It is a parabolic PDAE-extension of the electric network equations, which includes the heat conduction along one dimensional macrostructures. Furthermore, it generalizes the standard concept of local thermal networks, since lumped thermal elements are included. The coupling of thermal elements is based on energy fluxes, whereas temperature dependent parameters (lumped or distributed) enter the device characteristics used as input in the differential-algebraic network equations. Overall, this defines a system of partial differential-algebraic equations (PDAEs). Mathematically, the AN is a dynamic boundary value problem, which can be elegantly rewritten as a generalized problem. On this foundation, the deduction of the physical principles such as passivity and positivity is simplified. And more profoundly, the existence and uniqueness of solutions to the according coupled thermal-electric problem can be deduced.

Numerically, the spatial limitation is conceptually wanted, and offers freedom by adaptivity. Co-simulation applied to a discretization by finite volumes does not suffer from any contractivity constraints. Hence a multirate version and a partially increased order is applicable. To exploit the huge difference in the time rates for the electric and thermal part, coupling from the fast electric to the slow thermal part is done via the energy exchanged during a macro step. Based on an averaging technique, this approach conserves energy and avoids interpolation and/or extrapolation of rapidly varying node potentials and currents.

The PDAE approach is validated for the test circuit shown in Fig. 1. It is based on several inverters that are shunt in feed-back configuration forming an autonomous oscillator. This unit drives a cascade of inverter stages in the second circuit’s part. The overall configuration may model a signal flow on chip, for example, a critical path: part one reflects the internal signal propagation, part two the signal amplification for the bus communication.

![Figure 1: Test circuits consisting of an oscillatory part that drives a cascade of inverter stages](image)
voltage source, are started instantaneously. In Fig. 2 (left-hand side) the first node voltage is shown for two thermal scenarios: chip running at room temperature (neglecting thermal effects), or at a temperature profile caused by the reduction of mobility (including thermal effects). Clearly, the two signals diverge, they run in different phases due to a temperature difference of about 40 K. Consequently, on-chip both signals are processed with different speed, and in the worst case the delayed signal is not available in the assumed clock rate, which generally causes a failure of the system.

The right-hand side of Fig. 2 shows the temperature profile of the circuit at a very early time. Since the heat conduction is slow and the finite volumes are adapted to the structures, the devices can be precisely identified; its scaling and spacing is clearly visible. Furthermore, one notices the enlarged power dissipation of the fifth device; this is due to the fact that it has to power, or drive, both the first driver and the first inverter in the line.

**Figure 2: Self heating and thermal evolution along one-dimensional SOI gate structures (left-hand side) causing signal delay in test circuit (right-hand side)**

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**Numerical Schemes for Transient Noise Analysis**

Transient circuit analysis is usually performed without taking noise effects into account. But due to the decreasing supply voltages and due to the increasing importance of parasitics, this is no longer possible. The signal-to-noise ratio is getting so small that the noise effects have to be simulated, too. In most simulators this is done within the small-signal analysis in the frequency domain, which means that only a linearization of the circuit is handled. Another approach is the non-linear frequency analysis for oscillatory circuits, which restricts the application to that special class of chips. To overcome this restriction, a non-linear noise analysis can be combined with the transient simulation of the circuit. The noise sources (including thermal noise $I_{th} = \sqrt{2kT/R} \cdot \xi(t)$ for a linear resistor and shot noise $I_{shot} = \sqrt{q|g(u)|} \cdot \xi(t)$ for a pn-junction) are shunt in parallel to the ideal, noiseless elements.

They are modeled as Gaussian white noise $\xi(t)$ in the time domain, scaled by a linear factor $\sqrt{2kT/R}$ with resistance $R$ of the resistor, temperature $T$ at equilibrium and Boltzmann’s constant $k$ for the resistor, and a nonlinear voltage-dependent factor $\sqrt{q|g(u)|}$ with elementary charge $q$ and characteristic function $g(u)$ for the pn-junction. This stochastic contribution to the differential-algebraic network equations leads to stochastic differential-algebraic equations (SDAEs).

The noise densities contain small parameters, and noise should not be dominant in well-designed real-world circuits. Numerical schemes that take advantage of this characteristic are employed for the computation of the so-called paths of the noisy signals. In a post-processing step the statistical moments of the signals can be computed.

Designing the methods such that the iterates have to fulfill the constraints of the SDAE at the current time-point is the key idea to adapt known methods for stochastic differential equations to SDAEs. This is realized by an implicit Euler discretization of the deterministic part, whereas the stochastic part is discretized explicitly. Then the Jacobian of the discrete system is the same as in the deterministic setting, but is in general solution-dependent and differs from path to path.

The smallness of the noise also allows special estimates of local error terms, which can be used to control the stepsize. The mean-square of local error
estimates in an ensemble of solution paths serves as
criterion of the local error. This results in an adaptive
stepsize sequence that is uniform for all solution paths.

This approach is illustrated by simulation results
for a ring-oscillator of three inverter stages built up of
MOSFET transistors (see Fig. 3), where only thermal
noise in transistors and resistors is considered. To make
the differences more visible between the solutions
of the noisy and the noise-free model, the diffusion
coefficients had been scaled by a factor of 1000.

Figure 3: Thermal noise sources (filled circles and dia-
monds) added to a ring oscillator network model

Numerical results obtained with the drift-implicit Eu-
ler scheme are shown in Fig. 4, where the nodal poten-
tial \( V(1) \) at node 1 is plotted versus time. The solution
of the noise-free system is given by a dashed line. On
the left side, the mean \( \mu \) and the boundaries of the con-
fidence interval \([\mu - 3\sigma, \mu + 3\sigma]\) are presented, where \( \sigma \)
is the estimate for the standard deviation. These quan-
tities are in fact moments of the solution and could be
obtained more easily by weakly convergent numerical
schemes. The mean appears damped and differs con-
siderably from the noiseless, deterministic solution. On
the right side, two sample paths (dark solid lines) are
shown. They cannot be considered as small perturba-
tions of the deterministic solution, phase-noise is highly
visible.

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Introduction

Advanced RF Simulation and Modeling (ARFSIM 2002–2003) was a national project funded by the National Technology Agency of Finland, Nokia, and APLAC Solutions. In the project, APLAC circuit simulation and design tool [1] was used as a common platform for the methods developed. The total volume of ARFSIM was 16 man-years: 8 at the Circuit Theory Laboratory of Helsinki University of Technology, 6 at Nokia Research Center, and 2 at APLAC Solutions. This paper briefly reviews the ARFSIM research carried out at the Circuit Theory Laboratory, which was divided into five subprojects to be described next.

Enhancement of existing analysis methods

Here, the overall goal was to improve the speed and/or convergence of DC, transient, Harmonic Balance (HB), and Large-Signal–Small-Signal (LSSS) analysis. The convergence of DC analysis was improved, e.g., by using a nonmonotone norm-reduction method with Newton-Raphson (N–R) iteration.

The transient analysis of APLAC was rebuilt based on an event-driven mechanism: abrupt changes in the (arbitrary) source waveforms are detected and the time step of numerical integration is carefully predicted. This computation and the truncation-error criteria developed enables fast progress towards the next event such that the number of time steps and, also, the number of N–R iterations is reduced remarkably. The speed-up of transient analysis for five industrial circuits is demonstrated in Fig. 5, where 7.62 and 7.91 denote the APLAC versions at the beginning and end of ARFSIM project, respectively.

The HB analysis in APLAC is based directly on the Modified Nodal Analysis (MNA) formulation (and not on separation into linear and nonlinear parts), which is useful due to the natural sparsity of MNA. Nonlinear-equation solution is performed with (inexact) N–R with the Generalized Minimal RESidual (GMRES) method. Since the iterative linear solver GMRES needs only matrix-vector products, a further increase in sparsity is possible. In fact, the dense nonlinear-element Jacobians (conversion matrices) are never assembled, but rather their products with vectors are represented using fast Fourier transforms. Consequently, given a number of frequencies, $N_f$, the overall time and memory usage have roughly $O(N_f \log N_f)$ complexity per iteration. The speed-up of HB analysis for five industrial circuits is shown in Fig. 6.

The LSSS/noise analysis is based on the linearization of the circuit equations about a time-dependent operating point obtained from HB analysis. Previously, the LSSS equations were solved using LU factorization. If the circuit and/or the number of frequencies is large, the memory consumption as well as the CPU time needed for sparse-matrix reordering grows rapidly. In order to overcome these problems, the iterative GMRES algorithm was applied to solve the LSSS equations, too.

Development of simulation methods for modulated signals

Multivariate Steady-State Time Domain (MSSTD) analysis aims to solve the steady state of a strongly nonlinear circuit excited by signals at two very different frequencies. MSSTD is a finite-difference method with two time variables and periodic boundary conditions.
In this subproject, MSSTD analysis was implemented in APLAC. Also, several improvements were proposed: a multigrid approach by gradually increasing the number of signal sample points, inexact-Newton method, GMRES preconditioners, and fine-tuning of the convergence-aiding methods. However, the conclusion was that MSSTD analysis is not, at least with these improvements (only), not robust enough for simulation of large industrial circuits.

Parallel hierarchical analysis

Efficient parallel DC and transient analysis methods were developed and implemented. In these methods, the circuit is decomposed into smaller blocks, thus allowing parallel hierarchical LU factorization of the resulting bordered block diagonal Jacobian matrix. The code developed runs both in Networks of Workstations (NOWs) and in multiprocessor computers. The speed of transient analysis with, say, four computers in NOW was nearly doubled.

In order to minimize the communication between computers in a NOW, we also studied methods like multilevel N–R, where iterations are performed at many (in our case, two) levels. Unfortunately, this slowed down the convergence such that the overall simulation took, usually, longer.

Also, parallelization of HB analysis using threads was investigated, with promising results.

Artificial neural network modeling

ANNs can approximate an unknown, nonlinear, multidimensional input-output mapping, once trained with an appropriate training set. The ANN outputs, y, are given by the mapping \( y = y(x, w) \), where \( x \) represents the inputs and \( w \) the ANN parameters, or weights, that are optimized during the training process.

An ANN-model generator was developed and implemented. The ANN-model generator enables ‘black-box’ modeling of any component (with known equivalent-circuit topology), for which the user has measurement or simulation data to train the ANN. Also, methods have been developed for scaling the training data such that ANN training becomes easier. Finally, radial-basis-function ANNs, which should be able to approximate rapid local changes in the data, have been studied, too.

Reduction of passive circuits

Packaging and on-chip interconnects unavoidably entail huge passive circuit models that slow down any simulation due to the large number of circuit equations. The goal was to find a method of reducing those large models to smaller ones with minimal loss of accuracy and maximal reduction of simulation time. Several methods were evaluated and the best method found, Passive Reduced-order Interconnect Macromodeling Algorithm (PRIMA), was implemented.

Once the frequency-domain reduced-order model has been obtained, it has to be linked into the transient analysis of the whole nonlinear circuit (see Fig. 7). To this end, we compared and developed various equivalent-circuit realizations for the time-domain simulation of the reduced-order models.

![Figure 7: Basic idea of model reduction.](image)

Discussion

In addition to the new/improved RF simulation and modeling methods in APLAC, our research work on the ARFSIM project also resulted in several theses and publications that can be found on the web pages of the Circuit Theory Laboratory [2]. Since all the parties were satisfied with the results of the ARFSIM project, a continuation project MOdeling and Simulation for Advanced Integrated Circuits and Systems (MOSAICS) was launched for the years 2004–2005. The total volume of MOSAICS is 18 man-years while our portion is 10 man-years. In MOSAICS, we will have two new subprojects. In the subproject “Model development”, the goal is to solve fundamental problems related to MESFET/HEMT channel charge and to develop and implement, e.g., an interface for converting higher-level Verilog-AMS model descriptions to C language. The other new subproject is “FDTD and analog co-simulation”.

Finally, the authors would like to thank Dr. Mikael Andersson (Nokia Research Center) and Dr. Olli Pekonen (APLAC Solutions) for fruitful co-operation.

References


Analogical and Electromagnetics Simulation at Philips Research

The description given next applies to Philips Electronic Design and Tools, Analogic Simulation. The department has a strong background in providing and supporting state-of-the-art algorithms and tools to the Philips electronics design community. It provides, develops and maintains tools for simulating electromagnetic problems, circuit designs and optimization. The activities focus on RF (Radio Frequency) problems and on mixed signal (analog-digital) circuit simulation. More and more, industrial design takes place using a design flow. This means that tools have to fit in such a flow and if so those are preferred ones. This also means that new algorithms can only contribute to an industrial success if they fit in the selected tools, or if they fit the design flow environment. A stand-alone algorithm is of little use when one cannot study tolerances, statistics, or sensitivities.

For RF designs in particular, many parts of the physical system, such as IC packages, PCBs (printed circuit boards) and printed components (and also the coupling between them), can only be simulated accurately using numerical electromagnetic field analysis. This also applies to interconnect structures on RFICs. In general, this results in very large matrix systems to be solved, which can be virtually impossible to do directly. In EM research goals are to gain insight into the problems of modelling IC interconnect (from EM solver viewpoint) and simulation of substrate noise analysis. For non-linear time-domain methods, we need to reflect the behaviour as a system of DAEs. There are a number of possible ways to couple this to the simulator. One can generate these equations directly from the S-parameters or via a behavioural modelling step. Model reduction techniques are important to combine interconnect with additional circuitry. Preserving stability and passivity are important issues here. Reduced order modeling replaces large systems by smaller, computationally more flexible ones, with approximately the same behaviour. Also, in order to be able to use the model in circuit simulation, the realization of an equivalent circuit is essential.

In circuit simulation providing RF simulation facilities was an important activity in the last years. Special topics dealt with (multi-tone) Periodic Steady-State analysis, free oscillator analysis, and periodic noise analysis. Periodic phase noise modeling heavily depends on Floquet theory. In mixed signal circuit simulation combined digital and analogue circuits are studied in the design phase. While in the digital part the logical states are of importance, in the analogue part one wants to obtain accurate results. Distributed tolerances imply multirate time integration. Here available mathematics is rather limited. One has to reconsider partitioning, integration strategies, and stepsize determination.

Another point for research here is model reduction in the time domain. For linear electromagnetic problems a lot of experience is still being built up in mathematical research, resulting in algorithms that preserve passivity. In mixed-signal simulation, in the digital circuit part, one encounters a strong switching behaviour and nonlinearity, which has to be treated in the time domain. Model reduction techniques are looked for that facilitates re-use with different values for parameters. Here mathematics still has to make her first steps.

In Optimization circuit sizing and layout optimization are covered. Currently deterministic approaches are based on Nelder-Mead and on a new augmented Lagrangian trust-region approach. The algorithms can deal with non-linear constraints and object functions. Also one can distinguish between more and less important targets and can switch obtained targets to become constraints in next analyses. Important issues are: non-differential and multi-extremal object functions, object functions that are expensive to evaluate, the occurrence of singular points at unknown locations and the fact that the object function can be contaminated by noise.

Furthermore, with all these considerations it is an even greater challenge to perform robust and efficient yield optimization. That is, optimization with varying process parameters and environmental parameters. Last but not least, the optimization approach should facilitate extensions to higher levels of design abstraction, enabling hierarchical optimization of larger designs.

Cooperation

Cooperation is with VectorFields Ltd (electromagnetic field simulation), and Cadence (circuit simulation enhancements). The department participates in the CODESTAR Framework V project "Compact Modelling of On-chip Passive Structures at High Frequencies" where we participate in the "Automatic generation of models for Passive Structures". With the Eindhoven University of Technology PhD-projects continue on the numerical mathematics for circuit simulation problems. With several other universities (The Netherlands, Germany, UK) various MSc-projects have been executed.

The department actively participates in the SCEE
conferences on Scientific Computing in Electrical Engineering that provide a platform where mathematicians and electronic engineers from academia and from industry meet to discuss progress in methods and mathematics in electromagnetics, circuit simulation, optimization and coupled problems. On a smaller scale also the minisymposia are stimulated at ECMI conferences, organized by the Special Interest Group on Scientific Computing in Electronics Industry. Finally, during the last years, networking was stimulated by involvement in the MACSI-net Working Groups WG02 (Model Reduction and Coupled Problems) and WG13 (Electromagnetics in Telecommunication).

References


Circuit Simulation at Infineon

Uwe Feldmann

Since circuit simulation has a long tradition in semiconductor industry, the question may arise why further development and even research in this field is necessary. We will use Infineon’s circuit simulator TITAN to highlight some of the problems. TITAN serves the whole spectrum of analyses in the time-, (nonlinear) frequency- and temperature-domain, inclusive stability-, sensitivity-, noise- and statistical analysis. As a simulation engine, TITAN can focus on algorithms and models, while data flow and user-interface are provided by embedding design environments (CAD systems). The driving forces for TITAN’s development are the progress of semiconductor technology, new design methods e.g. for high frequency data transmission, the trend to integrate systems on chip, and the use of circuit simulators as a black box tool in mass applications [4]. The first aspect requires continuous improvement of models - which are not discussed here - and of performance. Another consequence is that device noise becomes more important, which is stochastic by nature. The second one requires to deal with widely separated timescales, the third one to introduce behavioral models, and the fourth one makes robustness of numerical methods extremely important.

Performance

Since classical algorithms of circuit simulation are perfectly tuned over the years, they are hard to beat in general, if the same degree of universality, robustness and accuracy is mandatory. Only recently developed one-step methods of ROW type turned out to be of similar performance, and moreover have some nice damping properties [6].

Speedups with the classical methods can be obtained by using table models, by exploiting latency (i.e. skipping those circuit parts, which have not much changed from their previous state), and by parallelism. Latency concepts need very careful implementation to be successful, and hierarchical linear solvers when applied to the sub-block level. TITAN’s standard method for parallel simulation is a two-level Newton concept. The circuit is partitioned into a ‘master’ circuit and subblocks; each subblock is solved on a separate processor, while the master process solves the carrier network [5]. The method is continuously being improved. Actually it is capable to run a 500k transistor circuit in a few hours on 16 400 MHz processors. The inclusion of all parasitic resistors and capacitors extracted from layout would make such large simulations infeasible at present. So model order reduction is applied before simulation starts.
Stochastic differential algebraic equations

As an alternative to noise analysis in the frequency domain - which is well established in the literature - the inclusion of device noise during time integration is desirable, if the circuit is not fully periodic or the impact of nonlinearities is not clear. The noise models lead to an additive stochastic term in the network equations, and turn them into stochastic differential algebraic equations SDAEs. A method for pathwise solution of the SDAEs is described in [2]. Actual research is focused on a timestep control which allows for an efficient computation of a large number of solution paths.

Behavioral modelling

Languages like VHDL-AMS [1] can be used for speedups and for inclusion of non-electrical models into simulation. The price is that the special structure of the network equations is destroyed, and the solver has to be upgraded for nonlinear DAEs of arbitrary structure and index. This is a hard task to achieve in practice. So we established a set of golden rules how to develop ‘reasonable’ models, and implemented corresponding rule checkers and debugging tools.

Robustness and diagnosis

For standard circuits with DAE index not greater than 2 the methods employed should be sufficiently robust to compute a solution. In case of failures identification of the critical circuit parts is desirable. For problems due to too high DAE index, the methods described in [3] give sufficiently sharp informations. For problems due to ill condition or numerically singular matrices extensions of the method described in [7] are being developed. Our diagnostic tools combine structural methods - which due to their graph-theoretical nature are fast enough for large circuits - with local(!) numerical criteria to make diagnosis sharp and reliable.

New topics of research

Much progress achieved in the past was based on fruitful cooperations with academic research groups, and we hope that these can be continued in the future. Possible directions of mathematical research can be derived from the visible trends in microelectronics: Increasing power density, shrinking device size and increasing frequencies require the coupling with thermal, device and field simulation. This has already been done in the past, but the mathematical foundation is still in the beginning. Another topic of interest is to exploit the multirate property of large circuits: Some parts of the circuit change rapidly, while others settle at much larger time constants. A third one is to deal with nonlinear model reduction and model verification. Finally, for diagnosis efficient methods for finding minimal cycles in weighted graphs are of interest.

Fortunately, some of these research topics were just started in a joint project at Berlin, Mainz and Wuppertal. We are grateful to German government for funding in the BMBF program ‘Neue mathematische Verfahren in Industrie und Dienstleistungen’.

References


MIRIAM Industrial days 2004 in Milan

The Industry Days are an effort of MIRIAM for establishing an ongoing "communication channel" between Academia (methods) and Industry (applications).

The intention is to reinforce awareness in both Academia and Industry about the increasing role of Mathematical Methods and Tools for the design of complex products in various areas of industrial interest at large (Mechanics, Electronics, Finance, Medicine, etc.). Mastering complexity demands that actors with different background share various tools, requiring in turn an increased level of communication between culturally different people.

The Industry Days offer to all interested researchers the opportunity to be exposed to the presentation of real industrial and social problems and the relevant innovative mathematical methods useful in their modelling; the need of further contributions from mathematics to improve or provide better solutions will also be considered.

Web page: http://www.mat.unimi.it/users/mirwork/

2003-2004 Industrial days:

Coding and Cryptography Milan (Italy) 1 December 2003


Random Geometries in Biomedicine January 16, 2004 (MACSI-net event)

http://www.mat.unimi.it/users/mirwork/RGiB/RGiB.html

Crystals (Formation, Growth and Simulation), Spring 2004

Financial Day, Fall 2004

For further information please contact:

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48th European Study Group "Mathematics with the Industry" (48th ESGI)

First announcement

The 48th European Study Group "Mathematics with the Industry" (48th ESGI) will be held at the Delft University of Technology in Delft, the Netherlands from March 15th until 19th, 2004.

Place: Delft Institute for Applied Mathematics (DIAM) EEMCS Building, Mekelweg 4 Delft, the Netherlands

Time: 15- 19 March 2004

Organization: H.X. Lin (DIAM), C. Kraaikamp (DIAM), C.W. Oosterlee (DIAM).

For more information, we refer to our website: http://ta.twi.tudelft.nl/swi

JOIN US TO TACKLE PROBLEMS FROM INDUSTRY! The study group brings together academic mathematicians and industrial commercial companies. Selected problems will be presented that mathematicians try to solve. At the end of the meeting the results will be presented.

49th European Study Group with Industry

Oxford, 29 March - 2 April 2004

The study groups will return to their roots when OCIAM hosts the 49th European Study Group with Industry in Oxford from 29 March to 2 April 2004. Some funding will be available via MACSI-net to support participants from outside the UK. Further details and application procedures will appear on the OCIAM web pages at http://www.maths.ox.ac.uk/ociam/ in January.
ESGI50 - Industrial Mathematics Workshop 24.5. - 28.5.2004

Industrial Mathematics Workshop ESGI50 (50th European Study Group with Industry in Mathematics) is organized at Helsinki University of Technology 24.5. - 28.5.2004. In this weeklong workshop professional mathematicians study real problems submitted by industry and business. The registration will begin March 2004. Workshop together with accommodation is free of charge to the participants (mathematicians).

More information
http://www.csc.fi/esgi50
or e-mail
esgi50@csc.fi

MMA 2004 9th International Conference Mathematical Modelling and Analysis

May 27 - 29, 2004, Jurmala, Latvia

Conference organizers

The European Consortium for Mathematics in Industry (ECMI) Institute of Mathematics, Latvian Academy of Sciences and University of Latvia University of Latvia Transport and Telecommunication Institute (Latvia)

Focus and aims

The Conference focuses on various aspects of mathematical modelling and usage of finite difference and finite element methods for numerical solution of modern problems of science and engineering. It aims, in particular, at fostering cooperation among practitioners and theoreticians in this field. Another very important aim of the MMA meetings is to assist in the creation and maintenance of contacts between scientists from West and East. Working language of the Conference is English.

The basic topics

Analysis of numerical methods for solving problems of mathematical physics; Application of numerical methods to engineering problems; Analysis of ODE and PDE problems and applications; Navier - Stokes equations and applications; Parallel algorithms and parallel computing; Scientific computation

The scientific program includes invited plenary talks (40 min) and contributed talks (20 min)

Abstracts and Proceedings

Authors are requested to send an abstract (maximum 1 page) before April 10, 2004. Instructions and a style file for the preparation of the abstracts are available at http://www.vtu.lt/rc/mma2004/abstr.html

Conference materials

The selected papers of the Conference will be published in the vol. 9 of "Mathematical Modelling and Analysis", Technika, Vilnius, http://www.vtu.lt/rc/mma/. All papers will be pair-reviewed

Local Organizing Committee

A. Buikis (Chairman, Latvia),
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Questions regarding MMA2004 should be addressed to e-mail: lzalumi@latnet.lv To receive the Second Announcement you must register at http://www.mma2004.lv or to fill the registration form and send it by e-mail

The health resort town of Jurmala is situated approximately 20 km from Riga, the capital of Latvia, on the shore of the Baltic Sea. Jurmala is a tourist town with many shops and restaurants and the prices seem very reasonable for those who traveling from the European Union. The general information about Latvia You can find on the WWW page (http://www.latinst.lv). More information about Jurmala at http://www.jurmala.lv
The International Conference "Inverse Problems: Modeling and Simulation"
June 07-12, 2004, Fethiye, Turkey

The First Announcement

The International Conference "Inverse Problems: Modeling and Simulation" will be held during June 07-12, 2004, in the historic city of Fethiye, on the Mediterranean Sea, in Turkey. The main aim of the Conference is to promote unity through diversity and to encourage worldwide interest in the theory and applications of inverse problems. Our forum is going to bring together leading scientists from many different countries and many speciality applications. The proposed International Conference will be under the auspices of such international journals as Inverse Problems, Inverse Problems in Engineering, Inverse and Ill-Posed Problems, and Computational Methods in Applied Mathematics. The organizers of the Conference, in particular the Fethiye Municipality, will work to put together an excellent scientific program with social programs consisting of tours to historic places and boat rides. We welcome you to the International Conference "Inverse Problems: Modeling and Simulation".

CHAIRS:
Heinz W. Engl (Radon Institute for Computational and Applied Mathematics, Austria)
Alemdar Hasanov (Hasanoglu) (Kocaeli University, Turkey)
Sergey Kabanikhin (Sobolev Institute of Mathematics, Russia)

Preliminary list of members of the INTERNATIONAL PROGRAM COMMITTEE (further members to be confirmed):
M. Bektemesov (Almaty, Kazakhstan)
M. Burger (UCLA)
A. Iserles (Cambridge, UK)
V. Isakov (Wichita State, USA)
A. Jaoua (Tunis)
R. Kress (Goettingen, Germany)
M.M. Lavrentiev (Novosibirsk, Russia)
Li Ta-Tsien (Fudan, Shanghai)
V.G. Romanov (Novosibirsk, Russia)
M. Pidcock (Oxford Brookes, UK)
G. Uhlmann (Univ. of Washington, USA)
V.V. Vasin (Ekaterinburg, Russia)
M. Yamamoto (Tokyo, Japan)
J. Zou (Chinese Univ. of Hongkong. China)

Main topics:
- inverse problems in geophysical sciences;
- inverse problems in underwater acoustics;
- inverse problems in signal and image processing;
- wavelets and inverse problems;
- inverse scattering problems;
- links between optimization and inverse problems;
- Monte-Carlo formulation of inverse problems;
- control problems and inverse problems;
- inverse problems in fluid dynamics;
- inverse problems in potential theory;
- determination of physical and mechanical properties of media;
- numerical simulation and analysis of inverse and ill-posed problems;
- regularization of ill-posed problems.

Deadlines:
Proposal of Special Sessions December 31, 2003
Abstracts January 31, 2004

Abstracts:
The abstracts of the Conference, consisting of the all lectures (one LaTeX page), will be published. All participants will obtain copies during the Conference. Abstracts are due by January 31, 2004 and should be sent to both of the following email addresses: nikolaus@indmath.uni-linz.ac.at, oznur@kou.edu.tr

Visas:
Visas are not required for participants coming from any country.

Hotel Accomodations
A large number of rooms will be reserved in various close hotels throughout Ovacik town, Oludeniz-Fethiye (www.oludeniz.org), one of the historical places of the Mediterranean Sea Region. The hotel rooms will be reserved at specially discounted rates, and all the hotels are within 5 to 15 min. walking distance of each other. The prices (between 300-600USD for a week) will include breakfast and dinner. All the hotels are 50 km from the international airport at Dalaman.
Participants, as well as accompanying persons, need to pay an additional USD 100 to the account of the conference for lunch, which will be served during the conference (meetings), and for transportation to/from hotels/palace of Culture. Due to the expenses involved all participants including speakers are required to pay the registration fee.

Registration Fee:

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Banktransfer:
Pamukbank, Izmit Branch, Izmit-Kocaeli, TURKEY Account No: 442-23867234 Account Name: International Workshop In the bank transfer please show your name, surname and the name of hotel you have chosen and keep the receipt.

Social Programs
Social Programs consist of Opening and Closing Ceremonies, Cocktail Party, Banquet and visits to historical places plus boat tours. There is no fee for registered participants.

Transportation
The hotels are 50 minutes from the international airport at Dalaman. Representatives of the hotels will meet participants at the Information Service of the airport. A Conference bus service will provide transportation on June 07, 2004, from the international airport at Antalya.

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The 13th Conference on Mathematics for Industry
21-25 June 2004 Eindhoven, The Netherlands

The conference will be held at the Eindhoven University of Technology. In order to have a broader scope of application of mathematics in industry, ECMI 2004 is jointly organized by ECMI and ENBIS (European Network for Business and Industrial Statistics). The conference will be devoted to mathematical and statistical modelling, analysis and simulation of problems arising in a practical context. In particular the following application areas have been chosen:

- Aerospace
- Electronic industry
- Chemical technology
- Life sciences
- Materials
- Geophysics
- Financial mathematics
- Water flow

On each of the main topics there will be invited lectures by distinguished researchers. Besides, the conference will have minisymposia on these topics, both invited and contributed ones. Moreover there will be an opportunity to present a paper or a poster. The topics will be clustered within 1-2 days, to accommodate attendees with less available time.

Who should attend?
The conference is intended for mathematicians, statisticians, scientists and engineers, both from industry and academia. ECMI conferences have a long-standing tradition of bringing together researchers from various disciplines, who work on often only seemingly different disciplines. The transversality of mathematics makes it a versatile tool in a large variety of applications, in particular when using it in computational modelling.

Contact
ECMI 2004 Conference Secretariat
Technische Universiteit Eindhoven
Email: congressoffice@tue.nl
Web: www.ecmi2004.tue.nl/
Impressions of the 17th ECMI Modelling Week

Eddie Wilson (Bristol, United Kingdom)

The 17th ECMI student modelling week was held at the University of Bristol last August. The meeting involved forty students and five instructors from thirteen different countries (see photo), who worked on mathematical modelling problems ranging from the dynamics of refrigerator valves to the farming of salmon. As in all years, the meeting was a life-forming experience for the participants and below we present just a few impressions of those who took part.

Marianna Nagy (Budapest, Hungary)

I learnt a lot about the life of students from other nations. The only problem was that the modelling week was too short! When we came to know each other a little bit better it ended. I think these 10 days were enough to get a feeling of how we (as mathematicians) can work together on real life problems. But I also spent 10 beautiful days in a nice city with students from all over Europe. It was a great experience for me.

Finn Erik Kolnes (Trondheim, Norway)

The ECMI modelling week was great fun. My group worked on a problem in mathematical finance. To me this was a new way applying the methods and theory I have learnt so far, and it also had an exciting flavour as many textbook examples limit their examples to problems from physics and chemistry.

Meeting applied maths students from other European countries was also nice. The social events like going to the pub, excursions and so on were great and we got the chance to learn drinking songs in five different languages. Don’t remember much of the Finnish one, though.

Nicole Marheineke (Instructor from Kaiserslautern, Germany) and Sabine Zaglmayr (Instructor from Linz, Austria)

The ECMI modelling week was a special adventure not only for the students, but also for us instructors. It was great fun to experience the enthusiasm with which the students worked on the given mathematical problems. The mixture of different educational and cultural backgrounds caused group dynamics which is quite unique.

Give 8 strangers an unknown industrial problem with an unspecified mathematical solution and participate in their progress: after the first days of disorientation the students get to know each other and work on the problem not only through the day but also in the pub-sessions at night! By overcoming hard mathematical disputes and moments of desperation and pure panic they grow together as a team. Finally, they are together able to formulate a mathematical model which they solve analytically and/or numerically according to their individual strengths. The nice final presentations of colourful and moving results are celebrated in a big international party of satisfied, relaxed, happy people - including us!

Tapio Leppälampi and Liisa Torikka (Lappeenranta, Finland)

When we arrived in Bristol, Finland was already quite cold. Because the weather was warm in England we got to enjoy some extra sunny days. The purpose of the week was to apply mathematics to model real-life industrial problems. However the week’s best offering was to become familiar with people from around Europe. In the evenings we checked a couple of pubs to test new sorts of beers, of course, because we were in England. We learned all kind of things from other cultures. Spanish and Mexican people are very lively and they like to party. English people like to have huge breakfasts with bacon, and Swedish, Finnish and Norwegian are great rivals! The week finished with a very good dinner and party.
Klaus Schmitz and Myriam Cisneros (Oxford, United Kingdom)

On arrival, Bristol typified an unknown and neutral place, far from our ordinary activities and worries. This special situation, the open heart of the organiser and locals, created the ideal atmosphere for working hard, but also the appropriate place to feel calm, open to know others and share social life, despite the language difficulties, preferences, culture, etc. Being together for seven days (and nights at clubs and pubs) reinforced links and established the basis for long-term friendship. The high peak of social life at Bristol was, for sure, the closing dinner. Everyone was joyfully, spontaneous and relaxed. We simply had a great time!!!!

Sergiy Pereverzyev (Kaiserslautern, Germany)

The ECMI modelling week is a completely different activity from other types of conferences and events organised for mathematics students. This is much more like real research, where the problems are not concretely formulated nor the solutions known in advance.

The international team of differently oriented students (the ones who prefer to deal with pencil and paper, and the ones who try to do numerical simulations first) were getting involved in trying to solve a "real world" problem. So, at first there is nothing: no mathematical formulas, no mathematical questions. But there is vague "engineering" information. Thus, we had an opportunity to walk the whole way from industrial problem to a mathematical model which can be treated by mathematical methods. And that’s why this activity is the most enjoyable and useful among the others. In a sense, the modelling week is a model of a perfect research: hard-working team effort, with breaks to refresh the minds and magnificent party at the end. Many thanks to the people who invented, support and organize this week each year!

Ariadna Farris and Laia Vilalta (Barcelona, Spain)

They are many things to say about Bristol and the modelling week. We both had an excellent time, and it was an experience we will never forget. Apart from the scientific work, we also had a very active social life. After each hard day of work we played football together before going out to our favourite pub Babushka. We will never forget the week we spent in Bristol, or the people we met there.

Aureli Alabert (Instructor from Barcelona, Spain)

The modelling week has been a new and profitable experience to me. It was exciting to see the energy of young well-prepared people dedicated to the modelling problem I proposed. The team was large, but still we managed to split the work into several sections that were assembled together later. The atmosphere was very friendly both inside the team and among all people involved. It was a very satisfactory week in all respects.

The next modelling week will be . . .

. . . held at Finland, Lappeenranta University of Technology on 13-21 of August 2004. The 18th ECMI modelling week at the Web: http://www.it.lut.fi/mat/modweek/
Symbolic regression - an overview

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Keywords: analytic programming, genetic programming, grammar evolution, evolution algorithms, symbolic regression

Introduction

Term "symbolic regression" (SR) represents process during which are measured data fitted by suitable mathematical formula like \(x^2 + C\), \(\sin(x) + 1/e^x\), etc. This process is amongst mathematician quite well known and used when some data of unknown process are obtained. For long time SR was domain only of humans but for a few last decades it is also domain of computers. Idea how to solve various problems by SR by means of evolutionary algorithms (EAs), come from John Koza who used genetic algorithm (GA) in so called genetic programming (GP) [1], [2]. Genetic programming is basically symbolic regression which is done by evolutionary algorithms instead of by humans. Ability to solve really hard problems were proved during time many times and GP is today on such level of performance that it is able to synthesise (for example) extremely sophisticated electronic circuits [3]. It is clear that importance of symbolic regression will increase due to increasing complexity of solved problems in science and industry. Main attribute of symbolic regression is that it is executed by evolutionary algorithms and whole evolutionary process is working with so called functional set and terminal set. Functional set is a set of all user defined or used functions while terminal set is a set of all constant or variables.

In this participation are discussed three different methods for symbolic regression - genetic programming, grammar evolution (GE) and so called analytic programming (AP), which is novelty tool for symbolic regression, based on different principles in regard of GP or GE. Higher attention will be dedicated to AP because of its novelty.

Symbolic regression and evolutionary algorithms - main ideas

Symbolic regression is in fact based on existence of so called evolutionary algorithms. This class of algorithms is based on Darwinian theory of evolution and one of its main attributes is that there is no calculated only one solution, but a class of possible solutions at once. This class of possible and acceptable solutions is called "population". Members of this populations are called "individuals" and mathematically said, they represent possible solution, i.e. solution which can be realised in real world application. Main aim of evolutionary algorithms is to find during evolutionary process the best solution of all. Evolutionary algorithms differ among themselves in many points of view like for example individual representation (binary, decimal) or offspring creation (standard crossover, arithmetic operations, vector operations, etc...) They also differ in philosophical background on which they were developed and usually they are named according to this point of view.

Symbolic regression is based on evolutionary algorithms and its main aim is to "synthesise" in an evolutionary way such "program" (mathematical formulas, computer programs, logical expressions, etc...) which will solve user defined problem as well as possible. While domain of EAs is of numerical nature (real, complex, integer, discrete), domain of symbolic regression is of functional nature, i.e. it consist of function set like (\(\sin()\), \(\cos()\), \(\gamma()\), MyFunction(),... ) and so called terminal set (t, x, p, ... ). From mix of both sets is then synthetised final program, which can be quite complicated in point of view of its structure.

In the novadays there are three methods allowing to do that: genetic programming, grammar evolution and analytic programming.

Genetic Programming

Genetic programming [1], [2] is oldiest method of automatic programme creation by means of genetic algorithm, which was developed by american informatic J. R. Koza (see also www.genetic-programming.org). This method is based on computer language Lisp which is able to manipulate with symbolic expressions. During existence of GP there was done by GP numerous examples like data fitting, logical expressions synthesis, robot trajectory optimisation, synthesis of a programme for artificial ant movement, system identification, etc. Main principle of GP is such that programs are represented in chromosomes like syntactic trees. Based on GA principles, trees are cutted by crossover operation and cutted parts are exchanged between themselves.

In this way there are created new individuals (offsprings), whose represents in fact a new programs which
are evaluated by fitness as is common in EAs. During creation of new individual-program there are also applied other operators like mutation etc.

Genetic programming also employ a new techniques like automatically defined functions (ADF), which can be specified like automatically defined iterations (ADI), automatically defined loops (ADL), automatically defined recursions (ADR), etc. Term "automatic" means that some functions created during evolution are automatically included into basic set of functions.

Grammar Evolution

Grammar evolution is the second method for symbolic regression which basically stems from GP. According to the author (C. Ryan, www.gramatical-evolution.org) GE is symbolic regression, which can be done by arbitrary programme language like Lisp, C++, Java, XML, Perl, Fortran, etc. In contrary with GP, grammar evolution is basically its extension which does not use direct symbolic representation in Lisp, but use so called Backus-Naur form (BNF). Based on BNF is GE able to do symbolic regression in above mentione computer languages.

During existence of GE there were done some comparative simulations based on problems solved by Koza in GP. For full texts please see www.gramatical-evolution.org.

Main Principles of Analytic Programming

Analytic programming (I. Zelinka, www.ft.utb.cz/people/zelinka/soma) was inspired by two existing methods: by Hilbert spaces and by GP. Principles and general philosophy of analytic programming (AP) stem from these two methods. Into AP an idea about evolutionary creation of symbolic solutions is taken from GP while from Hilbert spaces idea of functional spaces and building of resulting function by means of searching process is adopted into AP. This process is usually done by numerical methods like Ritz or Galerkin methods are [4]. Core of AP is based on set of functions, operators and so-called terminals, which are usually constants or independent variables as well as in GP and GE. Main aim of AP is to synthesise suitable program (mathematical formulas, for example see results of AP (1)-(4)) which would fit measured data as well as possible. For this reason a discrete set handling idea was adopted into AP. Discrete set handling (DSH) was proposed in [5], [6]. In analytic programming DSH is used to create integer index, which is used in evolutionary process like alternate individual, handled in EA by method of integer handling [5], [6]. An individual is created automatically in population like integer individual whose parameters range cannot exceed the cardinality of used set of functions and terminals.

\[
\frac{1}{1 + (\sqrt{1 - cac | \cot | t ||^2 \sin | \cot | t ||})^{2t}}
\]  (1)

\[
\frac{1}{1 + (\sqrt{1 - \frac{1}{2t}})^{2t}}
\]  (2)

\[
x^2 - 4.44089 \cdot 10^{-16} x^3 - 2.64 \cdot 3.33067 \cdot 10^{-16} x^5 + 1.6 x^6
\]  (3)

\[
\frac{1}{4.469 - (1.988 \cdot 10^{-1})x + 2.18x^4} \\
((1.882 \cdot 10^{-2})(3.112 - 1.x) \\
(-1.315 + x)(1.363 + x)(2.521 + x) \\
(3.195 + x)(3.057 + x + (4.843 \cdot 10^{-3})x^2) \\
(-4.685 - 1.634x + x^2))
\]  (4)

Today AP exists in three versions. All three versions need for program synthesis the same sets of functions, terminals, etc as Koza use in GP [1], [2]. The first basic version called AP\textsubscript{basic} is basic version of AP. It use constants from terminal set to synthetise programs in the same way like Koza [1]. The second one - AP\textsubscript{meta} is modification in the sense of constant estimation. In comparing with AP\textsubscript{basic} in AP\textsubscript{meta} only one nonspecified constant "K" is generated instead of randomly generated constants. Constant "K" is after synthesising indexed so that \(K_1, K_2, \ldots, K_n\) are in formula obtained and then all \(K_n\) are estimated by different or by the same evolutionary method. Because EA "works under" EA (i.e. EA\textsubscript{master} | program | K indexing | EA\textsubscript{slave} | estimation of \(K_n\)) then this version is called AP with metaevolution - AP\textsubscript{meta}. Last modification is AP\textsubscript{nf} which is based on AP\textsubscript{meta} is such that instead of other EA is K estimated by suitable non-linear fitting method. To verify that AP is viable there were done simulations - experiments that were for each case many times repeated, see [7], [8] and [9]. All simulations, especially the last one comparative, has showed that AP is able to solve the same problems like GP or GE at the same level of quality.

Conclusion

The method of symbolic regression described here are of three kind. The first one, genetic programming, is the oldest one and can be used only by genetic algorithms
and Lisp programme language. The second one, grammar evolution is “unfolding” of a genetic programming so that instead of Lisp there can be used different computer programme languages. However, grammar evolution still use binary representation of individuals and crossover operations like genetic algorithms use. The third method, called analytic programming, is independent on programme language and can be used by any evolutionary algorithm, does not matter how new offspring are calculated.

It can be stated that all three algorithms can be used for symbolic regression tasks and their hierarchy is such that on the lowest level is genetic programming (due to the ability to be used only by Lisp and genetic algorithm), on the higher level is grammar evolution (due to the possibility use different computer languages) and on the highest level is analytic programming (due to ability to be used not only different computer languages but also by any evolutionary algorithm like differential evolution (DE), simulated annealing (SA),...).

For complete information about all three methods it is recommended to see literature at the end or visit homepages of all three methods, i.e. for genetic programming: www.genetic-programming.org, for grammar evolution: www.gramatical-evolution.org and for analytic programming: www.ft.utb.cz/people/zelinka/soma.

References


On the waiting time to successful experiment using age-dependent branching model

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Statement of the problem

The goal of this work is to explain some puzzling phenomena and answer questions of interest for biotechnologists and environmentalists. First, how long does take the final establishment of bacterial cultures in wastewater laboratory experiments? As there is always a positive probability of extinction, it is possible to have several unsuccessful trials before the bacterial cultures start to grow irreversibly.

Secondly, what conclusions can one draw from an early extinction of a bacterial culture in different types of wastewater? Does it imply that the offspring mean in these environments is low? Similarly, our study might help decision makers to take a choice based on comparative laboratory results in one and the same environment cultivated with different bacterial strains. In general, such questions related to real world problems of industrial wastewater treatment are hard to answer. One of the major reasons for this difficulty is that the circumstances under which the experiments are made in natural and artificial basins, like lagoons, ponds and lakes, are not always the same.

We present an age-dependent branching model (see Athreya and Ney (1972)) with immigration and analyze how one can extract exact information about some
important characteristics of this model, as the mean reproduction and total progeny. On the other hand, using that model, we treat the problem of inference from expected waiting times and expected progeny on the fertility rates. Such application of age-dependent branching processes in the context of the real world ecological problem is natural since Powell (1955) found that the lifespan of bacteria follows a gamma distribution, and reproduction at death is characteristic of bacteria-like organisms.

The problem of inference from expected waiting times and expected progeny on fertility rates, was first treated by Bruss and Slavtchova-Bojkova (1999). In their article the simple case, in which all newly introduced populations are supposed to behave like independent identically distributed Bienaymé-Galton-Watson branching processes was studied.

We discuss an example of "extinction bias" which may mislead decision makers in cultivation experiments. One must be very careful not to draw hasty conclusions after failed experiments. To be specific, suppose that three different types of bacterial culture (α, β, γ, say) were introduced in similar wastewater and that each of these seems to have disappeared after some time, but that the α-type strains were reported in highest numbers or over the largest period of time. Is it then most promising to bet on α-type bacterial culture for a new experiment? The frequency of reports must be thought of as being positively correlated with the total progeny and the later with the reproduction mean of that bacterial culture. However such a conclusion would be erroneous, as we see in the following example. It is the number of times the process becomes extinct before it grows irreversibly, that will help to decide if the process is sub- or supercritical.

**Example**

Let \( f_p(s) = p + 0.35s + (0.65 - p)s^2 \) be the p.g.f. of the reproduction law of a Bellman-Harris process parametrized by the probability \( p \) that the initial progenitor dies without any offspring. The case \( p = 0.325 \) corresponds to the critical case \( m = 1, (0 < p < 0.325 \) supercritical, \( 0.325 < p \leq 0.65 \) subcritical). Clearly, \( q = q(p) \) is the smallest solution of

\[
q = p + 0.35q + (0.65 - p)q^2 \text{ in } [0, 1]\]

or \( q = \min\{1, \frac{p}{0.65 - p}\} \), and \( m = m(p) = f_p'(1) = 1.65 - 2p \), which decreases as \( p \) increases, whereas

\[
E(N_\infty | T < \infty) = \frac{1}{1 - f_p'(q(p))} = \frac{1}{2|p - 0.325|},
\]

which in the supercritical case increases as \( p \) increases.

It is worth noting that within this family of p.g.f.'s, in the supercritical case \( p < 0.325 \) the effect of conditioning on ultimate extinction is that \( f(qs)/q \) is another member of the family with \( p \) replaced by \( 0.65 - p \). That is why if the supercritical process does die out then it is impossible from the statistical point of view to distinguish it from the subcritical one.

**Conclusion**

Extinction entails a very strong bias. If a decision maker decides to try again with that strains (α-type) which seems to have been best adapted so far he may exclude those strains with a much higher fertility rate \( m \). The point is that he has to take that decision after extinction. It is simply very improbable that a process with a "comfortable" mean \( m > 1 \) would die out late. The higher the mean of a population the more probable it becomes that this population would, after extinction, be excluded from further experiments.

We conclude that the problem is of a greater significance that it might appear at the first sight. Independent control studies to assess prior probability of extinction are likely to be environment-bias.

**References**


Position Paper Concerning the Study Program Technomathematics

Dresden (Germany), September 11-13, 2003

1 General Statements

• Mathematics as a scientific field in conjunction with its large variety of applications, turns out to be one of today’s key skills. Products and processes of different kinds are more and more developed and designed by means of mathematical modelling starting from the initial concept up to manufacturing and service. The scientific education and qualification required for this purpose can be provided by the study program "Technomathematics" offered by a number of universities.

• The study program "Technomathematics" is offered by departments or faculties of mathematics at (technical) universities. Technomathematicians have a profound mathematical knowledge oriented to a broad spectrum of applications in the fields of engineering and natural sciences. Their main area of deployment is characterized both by mathematical modelling and by analytical and numerical evaluation of such models involving the assistance of computer facilities, i.e. by simulation, optimization, monitoring and controlling of technical processes.

• In industry as well as in other branches of the economy the demand for trained and qualified mathematicians of this type is currently very high and still increasing.

• Based on the interaction of mathematics, engineering, natural sciences and computer science on one hand and problems arising in industry and technology on the other, synergy effects arise, which should be harnessed already in the education process of students.

• Exposure to the highly complex interplay between mathematics, engineering sciences and computer science has to begin already during basic studies and has to be emphasized and developed further during graduate studies. Industry and economics as sources of relevant problems defining the profile of the professional activity of a technomathematician, should be integrated into the study program as much as possible. For that industrial practical training and special seminars, focussing on mathematical modelling, and finally also a suitable choice of a final thesis topic are appropriate tools.

2 Mathematics

• Basic studies (first two years) concern the basic subjects of mathematics.

• In the advanced stage of study the students must have the opportunity to choose mathematical courses with interdisciplinary activities.

• Modelling of real life problems has to be learned as part of the study program at the university, say in modelling seminars, workshops etc. The best way to achieve this goal is close cooperation with industry and appropriate research institutions.

• The students are offered final theses with an application background.

3 Technology

• The education of a technomathematician in the field of technology should concentrate on one particular engineering discipline, chosen early in their basic studies and continued into graduate studies.

• The education of technomathematicians in their chosen engineering field should be provided by the respective faculty of engineering at the university and is to be organized jointly with the other engineering students. This approach enhances communication of technomathematicians with engineers and experts from other fields. So, students of technomathematics acquire necessary knowledge and skills as well as the engineering terminology and the way of engineering approaches at least in the chosen technical field.

• The choice of the particular technical field in which the technomathematicians will be educated depends on the spectrum of specializations and op-
opportunities offered by the local engineering departments.

- The complete study program "Technomathematics" can be offered only at a university or a technical university, which is able to provide a depth and broad mathematical education at a suitably advanced level (e.g. if a diploma program in mathematics is offered). The institution has also to provide at least one engineering science program represented in teaching (introductory and special lectures, tutorials, seminars etc.) and in research (university professors, staff, labs, equipment etc.), possibly in cooperation with a different institution.

4 Informatics

- Simulation, optimization, evaluation and control of scientific, technical, economic and other systems and processes require the use of computers. Computers are an effective tool, which any technomathematician needs to be able to employ efficiently. To achieve the necessary level of skills he or she has to gain sufficient knowledge in informatics focussing on a professional use of computers and also elements of high performance computing.

- Therefore, already during the first years at the university the student has to be trained in applying computers for various tasks such as programming, visualization, and data management.

- It is recommended to combine such computer training with solving practical problems and with modelling activities right from the beginning.

5 Industry

- For a high-quality education of technomathematicians research contacts and research cooperations of scientists at the department or faculty of mathematics with industrial enterprises are indispensable and have to be integrated into the education process.

- Through the involvement of engineering sciences there is a natural influx of many unsolved, relevant technical problems into the education process. These opportunities have to be utilized consistently. They can, however, not be used as a substitute for direct contacts with the industry.

- Current industrial research projects (the department or faculty of mathematics is involved in) should be utilized to extract manageable problems to provide topics for modelling seminars, industry days, summer schools and final theses.

- Apart from high mathematical standards, an applied engineering, industrial or business background should be identifiable in the final thesis, which concludes the (4-5 years) study program in "Technomathematics".

This position paper was worked out in the discussion of the "International Workshop on the Study Program "Technomathematics" at the Technische Universität Dresden, September 11-13, 2003.

The participants from the 30 universities passed this paper by acclamation:

Austria

Technische Universität Graz
Institut für Mathematik

Johannes Kepler Universität Linz
Technisch-Naturwissenschaftliche Fakultät
Institut für Industriemathematik

Czech Republic

Brno University of Technology
Faculty of Electrical Engineering and Communication
Department of Mathematics

University of West Bohemia Plzen
Department of Mathematics

Czech Technical University, Prague
Faculty of Civil Engineering
Department of Mathematics

Estonia

Tallinn Technical University
Department of Mathematics

Germany

Universität Bremen
Fachbereich Mathematik und Informatik
Zentrum für Technomathematik

Technische Universität Chemnitz
Fakultät für Mathematik

Technische Universität Clausthal Gemeinsame Mathematisch-Naturwissenschaftliche Fakultät Institut für Mathematik
Mathematics at the
Universitat Autònoma de Barcelona

The Universitat Autònoma de Barcelona, (Autonomous University of Barcelona UAB) is a 30 years old university. It is publicly funded, and located at 15 Km from Barcelona. A good network of motorways and public transport connects the campus to the city centre in half an hour.

Studies

The UAB includes a wide range of faculties and departments, from Social Sciences and Humanities to Experimental Sciences, Engineering and Health Sciences.

Currently it offers 75 first and second cycle diploma and degree courses, 76 doctoral programmes and about 300 on-going training courses. The university has over 45,000 students and around 4,500 teachers and service administration staff. The UAB hosts more than 2,500 students from abroad every year.

Research

Research is a cornerstone in the life of the university and in its links with other institutions. There are many research centres located on the campus: Computer Vision, Microelectronics, Artificial Intelligence, Neuroscience, Material Science and Engineering. This fact guarantees the cross-fertilization of knowledge and experience. In addition to the resources assigned specifically to research, co-operation with companies using the latest technology and with other public and private institutions, research centres and institutes of applied technology all contribute to make the University a leading research institution. The construction of the Synchrotron Light Laboratory, which will be operating in 2008, will open a big range of new opportunities for high-level scientific and technological work.

The department of Mathematics

The faculty staff of the department consists of 60 permanent professors, all with PhDs in Mathematics, 30 lecturers/instructors, and 30 graduate students or fellow grants. The Department is responsible for the teaching of essentially all of the maths courses in the bachelor, diploma and engineering degrees of the UAB; specifically:

Faculty of Sciences: Mathematics, Statistics, Physics, Chemistry, Biochemistry, Biology, Biotechnology, Environmental Sciences, Geology, and Geography


The Ph.D. programme offers basic preparation for mathematical research in Algebra, Analysis, Statistics, Probability, Geometry, Topology and Applied Mathematics. About 15 courses are offered each year. An average of 6 students per year obtain the degree PhD in
Mathematics. There are fellowships for international students founded by the Ministry of the Universities, Research and Society of the information of Catalonia, in the context of the International Graduate School of Catalonia (IGSOC).

The department offers different masters program. We would like to point out the master programme Mathematics for Financial Instruments, which has been offering, since 1998, specialized preparation in Financial Mathematics. Including practical training in the stock market and banks, it provides student with modern mathematical techniques to be used for the evaluation of financial risks, pricing of options and portfolio optimization.

Research activity. There are 12 consolidated research groups in the department and these have developed a number of research projects supported by public and competitive funding, some of them developed in association which other research teams through EU supported agreements. Every group runs a weekly seminar throughout the academic year. Some of the topics are Dynamic Systems, Stochastic Analysis, Statistics, Partial Differential Equations, Harmonic and Complex Analysis, Algebraic and Arithmetic Theory...

The department has its own preprint series and has published since 1979 a mathematical research journal of general scope, Publications Matemàtiques, a volume (two issues) per year.

The Department of Mathematics offers support to industries and laboratories in those technical aspects that can be treated with mathematical tools, through its Consulting Technical Office for Companies and Industries.

Centre de Recerca Matemàtica

The Centre de Recerca Matemàtica is a mathematical research institute belonging to the "Institut d'Estudis Catalans" and the Ministry of Universities, Research and Society of the Information of Catalonia. With no permanent faculty, the CRM hosts foreign visitors for mid term or long-term periods to encourage research collaboration with local professors. Through an agreement with the Universitat Autònoma de Barcelona, the CRM has been located near the mathematics Department since 1984. An average of 45 foreign professors visit each year the CRM.

The degree of Mathematics

At present time, the mathematics degree is obtained after completing 300 ECTS in 4 years and half, and it is intended to provide a basic and general preparation in Mathematics. In the fourth year, the students can optionally study a "Minor" on more specific topics. The minors have 84 ECTS and up to 49 can be attended simultaneously with the basic degree. We would like to single out here the Minor in Mathematical Engineering and the Minor in Mathematics for the Economy. Twenty years ago, almost all graduates in Mathematics went to work as secondary teachers, or university teachers and researchers. Currently, at least half of the graduates work in industry, engineering consulting, banks, etc.. The minors were introduced in order to fill the gap between the theory-based programs and the needs of industry. We are working now to adapt the structure of the mathematics degree to the Bologna scheme. There is a Spanish committee, which has the objective of designing a basic common core mathematics curriculum; it is envisaged that we will begin the new Bologna curriculum during the course 2005-06.

Catalonia, Barcelona

The country of Catalonia, with six million inhabitants, lies in the northeast of Spain. Catalan and Spanish are both official languages. Catalonia offers, in a small area of 32,000 Km², a great variety of landscapes, ranging from sunny beaches to the high peaks of the Pyrenees. Barcelona, the second largest city in Spain, and the capital of Catalonia, is located on the shores of the Mediterranean Sea. Founded by the roman’s more than 2,000 years ago, it maintains a rich historical heritage and deeply rooted cultural traditions. Everyone identifies Barcelona as the city of Gaudi; his best-known works are the Pedrera, the Sagrada Familia and the Park Guell. Many other architectural treasures can be admired in Barcelona, from Gothic to splendid modernism, rationalism, and striking contemporary achievements. In the sphere of art, Barcelona offers also a wide range of possibilities: classical music, opera, and ballet; one of the best collections of Romanesque Art of the world, the Picasso museum, the foundations of Joan Miró, Antoni Tàpies and Tyssen-Bornemisza, or the new museum of contemporary art by Richard Meier.
Some Recent Activity in Industrial Mathematics and Statistics in Bulgaria

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The development of the Industrial mathematics preceeds the creations of research group of mathematicians and engineers from the Technical University of Sofia, the University of Sofia and South-Western University of Bulgaria.

This group concentrates its investigations in the field of some important and actual problems in Sewing Industry, Pharmaceutical Industry, Heat Mass Transfer Technic and Robotics. Below the list of the short abstracts of the most interesting problems solved in the last couple years is presented.

Experimental Design and Optimization of the Damp-Heating Process in Sewing Industry

The paper discusses the optimization of the continuance of the Damp-Heating Process of a steaming iron press machine, and the preserving of the lustre of the fabrics. In order to be obtained high qualitative damp-heating processing, it is necessary to monitor parameters such as temperature, damp, and pressure during the process. The purpose of the present paper is a mathematical model to be constructed that adequately describes the technological process using multifactorial study. It was established that the full factorial design of type 23 is not adequate. The research has proceeded with central rotatable design of experiment. The obtained model adequately describes the technological process of damp-heating treatment in the defined factor space. The present investigation is helpful to the technological improvement and modernization in sewing companies.

Mathematical Modelling of Two Processes in Sewing Industry

In the study the optimization of two types of sewing materials transportation processes is considered. The theory of the experimental design is used for building adequate models and for estimating the parameters of the models. The multicriterial optimization for obtaining the optimal values of the predicates and the predictors of the models is applied. The studied variables are the strength of stretching of the needle thread (SSNT) and the slippage of the materials (SL). SL depends also on three factors: the step of the stitch row, the force of the presser foot and the frequency of spinning of the main cylinder of the sewing machine. SSNT depends on three factors, which are the thickness of the sewed materials, the Tex-linear density of the thread and the frequency of spinning of the main cylinder. The choice of the factors is made using the literature and the expert’s opinion.

As a result of the central rotatable design of experiment adequate models are obtained. The source of the data are from four types materials: cotton, linen, wool and synthetics. The results are used for the increase of the productivity and the quality of the sewing operations in the textile factories in towns Yambol and Blagoevgrad, Bulgaria.

Fuzzy Logic Diagnostic System for Knitting Machine and Process

In this paper the background for building fuzzy expert system for diagnostic of knitting machines is presented. The approach use fuzzy linear system of equations for describing the diagnostic rules. The parameters, which describe faults in the knitting process, are quite different. The yarn tension changes continuous inside a wide range of values. The loop sinking cold be changed too, but the range is another, not comparable with range of yarn tension. The needles can be normal and broken, there is hole or not in the fabric, and both of these parameters could be characterized with classical 0 or 1 as states. All these parameters have to be treated at the same time with one method. In order to allow this, all of them have to be normalized using fuzzy membership function. Different amplitudes of input parameter changes are normalized using fuzzy membership functions. The causes of defects are found solving fuzzy linear system of equations.

Mathematical Procedure for Analysis of Data for Drug - Protein Binding

A new approach for analysis of the binding of a protein (human serum albumin) and drug molecules, when the data are obtained by Circular Dihroism Titration Method (CDTM) is reported. This is an optimization algorithm for estimating the number of classes of binding sites and association constants, which based on regres-
sion with constrains over the parameters. The procedure estimates also the concentration of unbound drug, which is unobservable. In addition the procedure allows an easy and natural way to choose the number of classes of binding sites based on F-criteria and residual sums of squares. The statistical properties of some of the estimated parameters are discussed. The results are applied to experimental data.

**Mathematical model of non-stationary heat convection of power-plant of non-piloted flying devices**

In the current work a mathematical model of non-stationary heat convection of power plants with liquid-rocket engines of non-piloted flying devices working at rate of strong throttling of the pulling power is represented. The process is modeled for using the final integral Hankel transformation for a hollow axially symmetrical cylinder with third kind boundary conditions on the inner and outer combustion chamber wall. The first five positive roots of the characteristic equation are localized on Maple V for Windows and the model function is graphically represented, and thus it becomes possible to prognosticate the intensity of the overheating of the chamber and the nozzle at starting the engine.

**Regression Multifactorial Analysis in Simulation Modeling of Robotic Industrial Systems**

The modelling and simulation the operation of robotics industrial systems allow performing a research in conditions close to the real cases. Thereby the cramped spaces are revealed and due measures are taken even at the designing stage. The present paper concerns simulation and research of the influence of various factors in order to receive an effective combination of robotic systems. The aim is to ensure a high coefficient of technical utilization of the components, which forms the structure of the robotic system. The most appropriate analysis of the results is the multivariate regression analysis. Based on the study and results obtained one can select a suitable structure of high efficient robotic industrial system.

**References**


Two of the listed papers have been presented at the annual International Summer School on Application of Mathematics in Engineering and Economics in Sozopol, Bulgaria and published in the corresponding Proceedings of this Summer School. The Proceedings are reviewed by Zentral Blatt fur Mathematik and Mathematical Reviews.

In 2004 this scientific event will celebrate its 30th Anniversary. All details about this event could be found at: http://www.tu-sofia.bg/FPMI/amee04
Support for Special Interest Groups

In its last meeting the Council decided to financially support Special Interest Groups (SIGs) of ECMI if they want to organize workshops. The maximum support per SIG will be 2.500 EUR. There will be 5.000 EUR available for 2004 for this kind of support. Applications (including a detailed budget) have to be sent to the ECMI Secretariat. The Board will decide about the amount of support.

ECMI Board from January 1, 2004:

President: Prof. Dr. Helge Holden
Vice President: Prof. Dr. Luis L. Bonilla
Past President: Dr. Hilary Ockendon
Secretary/Treasurer: Prof. Dr. Andreas Neubauer

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Ausschreibung der Stelle eines/r Universitätsassistenten/in (eines/r wissenschaftlichen Mitarbeiters/in im Forschungs- und Lehrbetrieb gemäß §94 Abs. 2 Z 2 UOG 2002) am Institut für Numerische Mathematik (http://numa.uni-linz.ac.at) der Technisch-Naturwissenschaftlichen Fakultät der Johannes Kepler Universität Linz.


Einstellungserfordernis ist ein abgeschlossenes Doktoratsstudium der Mathematik, Technischen Mathematik oder Technomathematik. Forschungserfahrungen im Bereich der Numerik partieller Differentialgleichungen und des Wissenschaftlichen Rechnens sind notwendig.


Nähere Auskünfte erteilt O. Univ.-Prof. Dr. Ulrich LANGER, Tel. ++43 (0)732/2468-9168.

Im Sinne des Frauenförderungsplanes werden besonders Frauen ermutigt, sich zu bewerben. Bei gleicher Qualifikation werden Frauen bevorzugt aufgenommen.

Bewerbungen mit den üblichen Unterlagen sind an die Personalabteilung der Zentralen Verwaltung der Universität Linz, 4040 Linz/Auhof zu richten.

Der Rektor: Ardelt

Memories — Newsletter Cover Design

On the following page we display the cover designs of the first four ECMI Newsletters. We hope that the enthusiasm of the early days could be recalled via these pictures. The decision to start publishing a Newsletter was done in a meeting at the small German wine-village Neustadt-Mussbach on April 13th to 14th 1986. The first two issues were produced at the University of Kaiserslautern by Helmut Neunzert and Marion Shulz-Reese. The symbol on the cover of issue 1 belongs to the village of Mussbach and its wines. Helmut suggested in his first "Letter from the publisher" that the donkey could become a good symbol for ECMI - a European animal, capable of carrying big loads, at times stubborn. The cover on the issue 2 displayed the "technomath symbol" of Kaiserslautern, the figure which so many of us have enjoyed to recognize on the campus afterwards.

I have had the inspiring responsibility of being the editor since issue 3 (except issues 12-13, due to a year abroad). The cover graphics at issue 3 illustrating "the network idea of ECMI" was drawn by assisting students at Lappeenranta. The European map with dots decorating the cover since issue 4 was produced by our Italians friends. The drawing was kindly brought to me by Vincenzo Capasso. Over the years the distribution of the black dots on the cover map tried to follow the evolution of the network. The new slightly revised cover design we designed together with by my assistant Liisa Torikka. The revision of the Newsletter design and contents continues. All help and suggestions from the ECMI community and interested collaborators are wellcome. Sincere thanks to all past and present contributors for their dedicated voluntary efforts in pursuing the common objective of building Europe and promoting industrial mathematics.

Keep your keyboards rattling.

Matti Heiliö
The Editor