Tenth Workshop
on
Mathematical Modelling
of
Environmental and Life Sciences Problems

Constanta, October 16–19, 2014

ROMANIAN ACADEMY
"Gheorghe Mihoc - Caius Iacob" Institute of Mathematical Statistics and
Applied Mathematics
Department of Applied Mathematics
Bucharest, Romania

"OVIDIUS" UNIVERSITY
Faculty of Mathematics and Informatics
Research Center of Applied Mathematics
Constanta, Romania

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Invited Speakers

Rafael Bru
Yair Censor
Stefania Petra
Florin Adrian Radu
Miroslav Rozloznik
Ulrich Rüde
Christoph Schnörr
Nicolae Suciu
Miroslav Tůma
General Schedule

Wednesday, October 15th, 2014 (Room AB1)

17.00-20.00  Registration and Welcome Party

Thursday, October 16th, 2014 (Room AB1)

09.00-09.30  Opening Ceremony
09.30-11.00  Communications
11.00-11.30  Coffee break
11.30-13.00  Communications
13.00-14.30  Lunch
14.30-16.30  Communications
16.30-17.00  Coffee break
17.00-19.00  Communications

Friday, October 17th, 2014 (Room AB1)

09.00-11.15  Communications
11.15-11.45  Coffee break
11.45-13.45  Communications
13.45-15.20  Lunch
15.20-17.50  Communications
19.00        Conference Banquet

Saturday, October 18th, 2014 (Room AB1)

08.30        Departure for excursion. Vis-a-vis of Hotel Megalos
18:00        Return to Hotel Megalos and free evening programme

Sunday, October 19th, 2014 (Room AB1)

Departure of some participants
Visits to museums in Constanț for the rest of the participants
## Conference Lectures

Thursday, October 16th, 2014 (Room AB1)

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Abstracts
Preconditioners based on the ISM factorization for least squares problems

by

Rafael Bru, Jose Marin, Jose Mas and Miroslav Tůma

In this work we study preconditioners based on the ISM factorization, which computes the LDU factorization of a matrix $A$ using recursion formulas derived from the Sherman-Morrison formula. In the first part, we study preconditioners which have been constructed successfully when there is no breakdown in the LDU factorization and we focus on preconditioners for least squares problems. In the second part, we present a modification in the recursion formulas of the ISM factorization that allows pivoting and so the construction of preconditioners for any nonsingular matrix. The ISM algorithm computes a vector at each step, by contrast, in the $k$th step, the new pivoting algorithm modifies all the vectors from $k$ to $n$. Thus, it can be seen as a right-looking version, with pivoting, of the ISM factorization.

A simplified theory of MHD generators

by

Adrian Carabineanu

The magnetohydrodynamic (MHD) generators transform thermal and mechanical (kinetic) energy into electricity. Unlike the traditional electric generators, they use hot electroconductive plasmas (ionized gases, liquid metals) and have no moving parts. In the last years, new applications of MHD generators to hypersonic aircrafts have been considered. In our paper we present a simplified theory of the MHD generators and calculate the output power.

Superiorization via feasibility-seeking projection methods and Applications

by

Yair Censor

The superiorization methodology is a novel approach to constrained optimization. Many iterative algorithms for finding a constraints-compatible solution are perturbation resilient in the sense that, even if certain changes
are made at the end of each iterative step, the algorithm still produces a constraints-compatible solution. This is exploited in the superiorization methodology by using permitted changes to steer the algorithm to a solution that is not only constraints-compatible, but is also desirable according to a specified objective function (criterion), although it not necessarily minimizes that criterion. The approach is applicable to many iterative procedures used in medical physics and other applications. Juxtaposing the superiorization methodology with the well-known subgradient projections method for constrained minimization reveals the motivation of the approach.

*Mathematical modelling of the load balance installed on marine cranes*

by

M. Cotrumba, E.M. Crăciun, F. Georgiadis and B. Radoiu

Our paper presents the compensation possibility of suspended load oscillations due to disturbances caused by ship, (eg. the ship rolling movement), initial perturbations (eg. sudden lifting of the load from the seating surface) or by random disturbances, (eg. wind gusts), with the cylinder of tilting crane arm. Writing the equilibrium equations at the load level we get a second order non-linear differential equation, *ie* the mathematical model is determined.

Simulations were carried out in Matlab software, using the toolbox of ”Simu-link Control Design” based on the mathematical model described by equation, linearized, for the real case of a cargo vessel of 7500 DWT on the wave of the Black Sea and the marine crane 882 097 type.

*Interface cracks in pre-stressed elastic composites*

by

Eduard-Marius Crăciun and Adrian Carabineanu

Our paper is devoted to mathematical models of the interfaces. Usually, mechanical interfaces are analyzed by employing the concept of a zero-thickness imperfect interface. To provide more realistic models of thick interfaces, Bigoni and Movchan have suggested modelling the structural interface which possesses a finite width and specific mechanical properties as a truly discrete structure.

Extending the Muskhelishvili’s formalism to the case of pre-stressed anisotropic materials and using the theory of Cauchy’s integral and Plemelj’s
function, we solve Riemann-Hilbert problem for boundary conditions which have to be satisfied on the faces of a crack, represented as a cut in the complex plane. We consider the mixed incremental boundary value problem for a pre-stressed elastic orthotropic material supposed to initial small deformations governed by the incremental equilibrium, constitutive equations and mixed incremental boundary conditions. We get the representation of incremental stress and displacement fields for an orthotropic, initial deformed composite material in plane and anti-plane states using complex potentials. In our work, using above model of structural interface we present a mathematical study regarding the behavior of an interface crack between two similar pre-stressed orthotropic elastic materials in first classical fracture mode and also we develop the study of the interaction of two collinear interface cracks.

Homogenization for Rigid Suspensions with Random Velocity-Dependent Interfacial Forces
by
Yuliya Gorb, Florian Maris, Bogdan Vernescu

We study suspensions of solid particles in a viscous incompressible fluid in the presence of random velocity-dependent interfacial forces. The flow at a small Reynolds number is modeled by the Stokes equations, coupled with the motion of rigid particles arranged in a periodic array. The objective is to perform homogenization for the given suspension and obtain an equivalent description of a homogeneous (effective) medium, the macroscopic effect of the interfacial forces and the effective viscosity are determined using the analysis on a periodicity cell. In particular, the solutions \( \approx_{\omega} \) to a family of problems corresponding to the size of microstructure \( \epsilon \) and describing suspensions of rigid particles with random surface forces imposed on the interface, converge \( H^1 \)-weakly as \( \epsilon \to 0 \) a.s. to a solution of a Stokes homogenized problem, with velocity dependent body forces. A corrector to a homogenized solution that yields a strong \( H^1 \)-convergence is also determined. The main technical construct is built upon the \( \Gamma \)-convergence theory.
Water flow on vegetated hill
by
Stelian Ion, Dorin Marinescu, Anca Veronica Ion, Stefan Gicu-Cruceanu, Virgil Iordache

A mathematical model of the water flow on a hill covered by variable distributed vegetation is proposed. The model takes into account the variation of geometrical properties of the terrain surface but it assumes the surface exhibits large curvature radius. Some theoretical properties of the model are presented and several reduced models are introduced. A discussion on several numerical approximation schemes ends the presentation.

The specificity of mathematical modeling in ecology and environmental sciences: the case of coupling vegetation models with erosion models
by
Virgil Iordache, Stelian Ion, Florian Bodescu, Aurora Neagoe, Daniel Scrădeanu

In this presentation we will defend the theses that the use of mathematics in the study of environmental systems is in fundamental ways different than its use in physics and chemistry, at least as long as we consider the environment being composed of coupled abiotic and biotic systems. This presentation roots in a series of theoretical publications (Iordache et al. 2009, 2011, 2012), but will be illustrated in its second part with practical methodological problems occurring in ongoing research project dealing with the inclusion of plant variables in erosion models. In short, while in physics and chemistry one can attempt to express the laws of nature (universal regularities) in mathematical terms, in biology and environmental sciences, although specific laws can be assumed to exist and to characterize a multi-scale system with very high dimensionality, one can only model some sub-spaces of the whole relevant productive space, and frequently only some part of the nomological space within a sub-spaces of the whole relevant environmental system. There are two complementary research programs in biology. In philosophy of science terms they are called ”reductionistic” and ”autonomist”. In the reductionistic paradigm one attempts to understand and model the biological and environmental systems in terms of variables specific to physics and chemistry. In this view (biochemistry, biophysics, systems ecology) there cannot be laws of the biological and environmental
systems different than the laws of physics and chemistry, or if there are
some regular patterns they are explainable and reducible in their nature to
the laws of hard sciences. For instance an ecosystems can be modeled by a
system of differential equations having as variable quantities of energy and
substance in different compartments of the system. It does not matter if
the compartment is for mammals or of bacteria or of plants, excepting some
general aspects like biomass, turnover rate of the biomass, etc. This kind
of approach has provided some insight in the general patterns of ecosystem
functioning, but was not able to allow any prediction or understanding of
patterns related to species diversity, functional diversity, its dynamic, etc.
In the "autonomist" approach one works in an irreducible way also with
variables specific to the organisms, communities, ecological systems, etc.
A well-known theory constructed in this framework is theory of evolution
(actually a system of interdependent theories, having as identity mark the
theory of selection). The autonomist idea grounds on obvious fact that some
variables simply do not make sense at smaller scales than the observation
scale (e.g. density of plants does not make sense at mm² scale). Although
populations of plants are composed of energy and matter, it does not make
sense in this view to assume that a variable like plants diversity can be re-
duced to flows of energy and quantities of atoms (this can tell something,
but it is too far from understanding the pattern of biological variables).
Another major difference is that the hierarchical theories are not assumed,
like in the reductionist approach) to be an instrument of reducing higher
level properties to lower ones, but they are simply a tool for coupling reg-
ularities (and models) existing (developed) at a certain scale with models
developed at another scale. It would make no sense to attempt to couple
in the same model variable observable only at very large scale (e.g. density
of bears) with variables observable only at very small scale (activity of mi-
croorganisms), as is the case in systems ecology. Anyway, the coupling would
not be direct, but would include some up-scaling and down-scaling models,
which in the case of environmental sciences would introduce intermediate
geographical objects and interpolation models between the measured vari-
bles. Data analysis of environmental data must take into account a series
of distinct characteristics of such data The problem of coupling an erosion
model with plant development models in a contaminated grasslands (main
points of Iordache et al. 2014, Neagoe et al. 2014, Căldărăuș et al. 2014,
Ion et al. 2014) allow us to substantiate the above statements. We will il-
strate the the processing of environmental data-sets include mathematical
models describing the natural regularities in part of the nomological space
of the system, but also must include many other instrumental models for
up-scaling, down-scaling or changing the discretization in space of the values of measured variables and of their way of representation in space), all of them part of an information system (environmental data base and portfolio of models for different purposes).

References


[6] Iordache Virgil, Radu Lăcătușu, Marilena Onete, Aurora Neagoe, Monica Stanciu-Burileanu, Florian Bodescu, Andrei Căldăruș, Iulia Dana, 2014, Modelling the bioaccumulation of Pb and Cu in grassland plants from a contaminated landscape, 13th symposium on remediation, Friedrich-Schiller University of Jena, Jena, Germany; 09/2014

**Multiple periodic solutions for the relativistic operator**  
by  
Petru Jebelean

We discuss the existence of multiple periodic solutions to $N$-dimensional relativistic operator

$$u \mapsto \left[ \frac{u'}{\sqrt{1-|u'|^2}} \right]'$$

in presence of both continuous and discontinuous potential perturbations. The talk is based on joint work with Jean Mawhin and Călin Şerban.

**Brinkman - Forchheimer - Darcy flow past an impermeable sphere embedded in a porous medium**  
by  
Gheorghe Juncu

The flow past an impermeable sphere embedded in a fluid saturated porous medium was studied numerically considering valid the Brinkman Forchheimer Darcy (or Brinkman Hazen Dupuit Darcy) equation. The flow is viscous, laminar, axisymmetric, steady and incompressible. The porous medium is isotropic, rigid and homogeneous. The stream function - vorticity equations were solved numerically in spherical coordinates system by a defect correction multigrid method. The influence of the Darcy number and Forchheimer constant on the flow field was investigated for two boundary conditions on the surface of the sphere: slip and no-slip.
A low-rank tensor-based algorithm for face recognition
by
Lăcrămioara Lită and Elena Pelican

The face recognition problem arises in a wide range of real life applications. Our new developed face recognition algorithm, based on Higher Order Singular Value Decomposition (HOSVD) makes use of only third order tensor. A convenient way of writing the commutativity of different modes of tensor-matrix multiplications leads to a new method that outperforms in terms of complexity another third order tensor method. The resulting algorithm is more successful (in terms of recognition rate) than the conventional eigenfaces algorithm. Its effectiveness is proved for two benchmark datasets (ExtYaleB and Essex datasets), which are ensembles of facial images that combine different modes, like facial geometries, illuminations, and expressions.

Measuring the hemodynamic flow in the brachial-ulnar-radial arterial system
by
Alexandru Morega, Cristina Savastru and Mihaela Morega

Variations in blood pressure in the arterial tree are commonly used to investigate the cardiovascular hemodynamic. The arterial blood pressure measurement (APM) is a non-invasive, safe, and easy to perform method that renders accurately the central pressure waveform. ABPM is evaluated through arterial blood pressure measurement (ABPM). The brachial artery is the place of choice for ABPM because this position is in the proximity of the aorta, and this location provides a good correlation of the measurement to the aortic pressure.

Oscillometric and auscultator ABPM methods are the standard in the assessment of the cardiovascular activity but they may not outline accurately the central hemodynamic status, which is associated with cardiovascular risks. Techniques based on pulse wave analysis such as the applanation tonometry (AT) may however provide detailed and accurate information on hemodynamic parameters that may be otherwise inaccessible. The AT is a waveform-based method inspired from the ocular tonometry, aimed at sensing the mechanical signals at peripheral artery level.
The areas of choice for AT are those where significant pressure gradients occur because these echo the events produced by atheromatous plaques. The brachial-ulnar-radial system, in particular the brachial bifurcation, is such a sensitive, favorite target area for the AT investigation of the hemodynamic flow. The radial artery pressure waveform is often associated with the central aortic waveform. Its dynamics may be recorded using sensors, e.g., piezoelectric and capacitive.

Numerical studies are usually conducted using idealized computational domains, but there is a concern on using more realistic computational domains built by using medical image based reconstruction techniques. Here we use both approaches, starting out of medical image data sets that represent part of the right arm of an adult. The model accounts for the arterial hemodynamic and the mechanical interaction with the arm. Several measurement stations are provided with capacitive (CPS) and piezoelectric (PZ) pressure sensors, which convert the reaction forces perceived by these sensors into electrical signals that outline the hemodynamic pressure waveform.

On the flow of an Oldroyd-B fluid with equal time constants in a Hele-Shaw cell

by

Gelu Paşa

G. Paşa and P. Daripa (2013) studied the linear stability of the displacement by air of an Oldroyd-B fluid in a Hele-Shaw cell. By using some appropriate scalings, it was obtained a formula of the growth constant of perturbations. This formula is given by a ratio, which contains in the denominator a term depending on \( \lambda - \lambda_1 \), the difference between the two time constants appearing in the constitutive relations of the considered Oldroyd-B fluid. In this short note we study the case when \( \lambda = \lambda_1 \). We prove that the basic flow corresponding to a constant pressure gradient far upstream is Newtonian, then the well-known Saffman - Taylor formula can be obtained.
Total-variation regularized tomographic reconstruction: How many measurements are enough?

by

Stefania Petra

Sampling patterns as used in industrial tomographical set-ups with limited numbers of projections fall far short of common assumptions in Compressed Sensing (CS). Thus, for such scenarios, CS provides neither theoretical guarantees of accurate reconstruction, nor any relation between sparsity and a sufficient number of measurements for recovery of sparse images from few tomographic projections. In this talk we investigate conditions for unique signal recovery based on cosparse signal models. We present an average-case relation between image cosparsity and sufficient number of tomographic measurements for exact recovery similar to the settings in CS and observe a phase transition as known from CS, but never established for the tomographic set-up. In addition, we present a large-scale total-variation minimization approach for reconstructing 3D solid bodies composed of few different materials from a limited number of tomographic projections.

(joint work with Andreea Denitiu and Christoph Schnörr)

Weaker hypothesis for the general projection algorithm with correction

by

Constantin Popa

In the paper [J. of Appl. Math. and Informatics, 29(3-4)(2011), 697-712] has been proposed a general projection-type algorithm with correction and has been proved its convergence under a set of special assumptions. The authors then obtained as particular cases of this general method, several well known extended projection-based iterations (Kaczmarz, Cimmino, Jacobi), but not the two-step algorithm analysed in [BIT, 38(2)(1998), 275-282].

In this paper we prove convergence of this algorithm under a much weaker set of assumptions. This new framework gives us the possibility to obtain as a particular case of our method also the above mentioned two-step.
Advanced simulation of flow and reactive transport in porous media
by
Florin Adrian Radu

Environmental pollution of groundwater and soil by organic compounds is nowadays a serious and widespread problem. A comprehensive active remediation often is not feasible from technical or financial reasons. Alternatively, in situ bioremediation (natural attenuation) has been recognized as a promising approach to restore sites contaminated with organic pollutants because it is less costly than active remediation strategies, the contaminants can ultimately be transformed to innocuous by-products with the help of microorganisms (not just transferred to another phase or place) and it can operate in situ. However, the decision to apply natural attenuation at a specific site depends essentially on the reliable prediction of the fate of the contaminant plume. Together with laboratory and field experiments, mathematical models can be used to predict the evolution of a site over long time periods.

We present a general mathematical model and mass conservative numerical schemes to simulate flow and the simultaneous reactive transport in porous media of an arbitrary number of organic substances in the presence of some microbial populations. The model includes the effects of advection, dispersion, sorption and degradation. The numerical schemes are based on mixed finite element method (Raviart-Thomas and Brezzi-Douglas-Marini elements), backward Euler and Newton linearization method. A stabilization scheme for convection-dominated problems and mixed finite elements will be also presented.

Gram-Schmidt process with respect to inner products and bilinear forms: rounding error analysis
by
Miroslav Rozloznik

In this contribution we consider Gram-Schmidt process used for orthogonalization with respect to the standard inner product, non-standard inner product or symmetric bilinear form and review the main results on their behavior in finite precision arithmetic. Probably the most straightforward and frequently used orthogonalization is the classical Gram-Schmidt orthogonalization, which consecutively orthogonalizes the new vector against previously computed vectors using the orthogonalization coefficients that form
the triangular factor. The vectors are computed via matrix-vector updates which are relatively easy to parallelize. The reorthogonalization of this scheme has led to the algorithm with better numerical properties. We will consider also other Gram-Schmidt schemes, developed in the context of non-standard inner product. Finally we discuss the extension of this theory to some bilinear forms used in the context of various structure-preserving transformations.

*Optimal algorithms for elliptic PDE in the presence of singularities*

by

*Ulrich Rüde*

Singularities in the solution of elliptic problems may give rise to the so-called pollution effect, i.e. on quasi-uniform meshes the error in the $L_2$ norm converges only with suboptimal rates. Optimal convergence can be recovered by the so-called energy correction that requires only a small change to the stiffness matrix is thus computationally less expensive than alternative techniques. The second part of the talk will discuss parallel multigrid methods for large scale finite element computations arising from the problem of Earth Mantle convection in geophysics.

*Graphical models for image analysis in life sciences and beyond*

by

*Christoph Schnörr*

Probabilistic graphical models provide a prevailing framework for mathematical models and computational approaches to image analysis problems across numerous application areas. It enables to seamlessly combine continuous, geometric and discrete aspects of the problem domain and to formulate basic tasks of model evaluation (inference) and model parameter estimation (learning) as variational problems in a canonical way. Although the systematic study of such models has started about three decades ago in the field of mathematical statistics, current problems of mathematical image analysis, in particular in spatio-temporal scenarios, raise numerous mathematical and computational issues. The talk sketches these general aspects along with a concrete recent case study concerning the extraction of retinal structures.
from 3D images obtained through optical coherence tomography.
(joint work with Fabian Rathke)

*Piezoelectric th-wave propagation in anisotropic solids subject to a bias*

*by*

**Olivian Simionescu-Panait**

Recent years, the problems related to electroelastic materials have attracted considerable attention, due their complexity and to multiple applications.

Last decade, we developed various dynamic problems concerning waves propagation in piezoelectric anisotropic solids subject to initial large static deformations and electric fields.

We study here a transverse-horizontal wave propagating in a semi-infinite piezoelectric solid with hexagonal symmetry and subject to initial large electromechanical fields. We solve the electromechanical boundary value problem, obtaining the phase velocity, the displacement and the electric potential. For a metallized stress-free boundary surface, we analyze the dependency of the solution on the initial fields for several piezoelectric crystals. Our results generalize the classical problem of Bleustein-Gulyaev wave propagation.

*Consistency issues in PDF methods*

*by*

**N. Suciu, F.A. Radu, S. Attinger, L. Schüler and P. Knabner**

Evolution equations for probability density functions (PDF) of the concentrations of chemical species are valuable tools in modeling transport in heterogeneous systems.

We consider an array of species concentrations $C(x,t) = \{C_\alpha(x,t)\}$ related by reaction terms $S(C) = \{S_\alpha(C)\}$, $\alpha = 1, \ldots, N_\alpha$, where $N_\alpha$ is the number of chemical species. For constant diffusion coefficient $D$, reaction-diffusion processes in statistically homogeneous random velocity fields $V$ with divergence-free samples, are governed by a system of $N_\alpha$ stochastic balance equations,

$$\partial_t C + V \cdot \nabla C = D \nabla^2 C + S(C).$$

(1)
The PDF $f(c; x, t)$ of the random concentrations $C$ solving (1) satisfies

$$
\partial_t f + \nabla \cdot (V f) = \nabla^2 (D f) - \nabla^2_c (M f) - \nabla_c \cdot (S f),
$$

where $V$ and $D$ are upscaled drift and diffusion coefficients and $M$ describes mixing by molecular diffusion. The most important feature of the PDF methods is that the reaction term $S$ in (2) is in a closed form, the same as in the balance equation (1) [1].

The numerical solution of the PDF equation (2) is usually obtained by solving a system of Itô equations describing the evolution of an ensemble of computational particles in physical and concentration spaces [2],

$$
dX(t) = V(X(t), t) dt + dW(X(t), t) \tag{3}
$$

$$
dC(t) = M(C(t), X(t), t) dt + S(C(t)) dt, \tag{4}
$$

where $C(t) = C(X(t), t)$, $W$ is a Wiener process with $E\{W(X(t), t)\} = 0$ and $E\{W^2(X(t), t)\} = 2 \int_0^t D(X(t), t') dt' \tag{3}$. The corresponding joint concentration-position PDF $p(c, x, t)$ solves a Fokker-Planck equation which is in general different from the PDF equation (2).

We introduce consistency conditions relating the statistics of the random field $C(x, t)$ to that of the stochastic process $\{X(t), C(t)\}$. Further, we propose a new approach to approximate concentration PDFs by solutions of Fokker-Planck equations, based on a global random walk algorithm, and we illustrate it for non-reactive transport in saturated aquifers.

References


Incomplete direct and inverse decompositions for preconditioning iterative methods

by

Miroslav Tůma

Incomplete Cholesky decompositions represent an important component in the solution of large sparse symmetric positive-definite systems of equations. Such decompositions arise in a wide range of practical applications. Preconditioners based on the decomposition combined with a Krylov-space accelerator are routinely used in a number of production codes.

Over the last 60 years or so, many different types of incomplete factorization methods have been developed. Some of them were inspired by particular applications and some intended to be more general-purpose. The enhancements of the basic procedure have varied from new mathematical ideas and algorithmic simplifications to more sophisticated implementations. If we try to systemize the decades of development, we could roughly classify them as offering improvements either in the accuracy of the $LL^T$ decomposition measured by a norm of the distance from the system matrix $A$ or in the stability of the computed factors.

Neither of these goals can be separated from the way in which the Cholesky decomposition is implemented. Consider, for simplicity, sequential implementations: we could state that a useful and robust decomposition can afford to spend $k$-times more time in the factorization than the simplest no-fill procedure for a small integer $k$. Having this flexibility in mind, one important challenge is to develop a memory-efficient incomplete Cholesky factorization. A possible answer to meet this challenge is to use the concept of intermediate memory introduced by Tismenetsky that led to contemporary successful implementations. Part of the talk will discuss such algorithms that offer good accuracy under the constraint of limited computational resources. Another challenge of contemporary incomplete decompositions is to find new ways to improve stability of computed Cholesky factors. A part of this talk will discuss new approaches along this line that may achieve improved stability by involving related decompositions of the matrix inverse. Further, another approach stabilizing an incomplete decomposition by a specific dropping will be presented. This dropping takes into account global numerical properties of the decomposition. Summarizing this, the talk will be an overview of some crucial problems faced in the field of incomplete decompositions and possible directions how these problems can be overcome.

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On a conjecture related to the ruin probability for nonhomogeneous insurance claims
by
Raluca Vernic

Recently, nonhomogeneous claim sizes have been considered in the actuarial literature starting from the fact that the claims are seasonally influenced by the economic environment. In this context, Raducan et al. (2014) obtained recursive formulas for the ruin probability at or before claim instants and stated a conjecture that relates the order of the claims arrival to the magnitude of the corresponding ruin probability, conjecture supported by numerical examples. In this paper, we prove this conjecture on some particular cases.

References

Virgil Iordache
University of Bucharest, Spl Independentei 91-95 050089, Bucuresti, Romania
e-mail: virgil.iordache@g.unibuc.ro

Petru Jebelean
West University of Timișoara
e-mail: 

Gheorghe Juncu
POLITEHNICA University Bucharest Department of Chemical and Biochemical Engineering Polizu 1, 011061 Bucharest Romania
e-mail: juncu@easynet.ro
juncugh@netscape.net

P. Knabner
Mathematics Department, Friedrich-Alexander University of Erlangen-Nuremberg, Germany
e-mail: knabner@math.fau.de

Lăcrămioara Liță
Ovidius University of Constanța, Romania
e-mail: lgrecu@univ-ovidius.ro

Florian Maris
Center for Numerical Porous Media, King Abdullah University of Science and Technology, Thuwal 23955-6900, Kingdom of Saudi Arabia

Jose Marín
Univesidad de Zaragoza, Spain
e-mail: razvan.maris@kaust.edu.sa

Jose Mas
Universidad Politècnica de Valencia, Spain
e-mail: 

Dorin Marinescu
"Gheorghe Mihoc–Caius Iacob” Institute of Statistical Mathematics and Applied Mathematics, Calea 13 Septembrie nr.13, 050711 Bucharest, Romania
e-mail: Dorin.Marinescu@ima.ro

Alexandru Morega
Faculty of Electrical Engineering, University POLITEHNICA of Bucharest, Romania
Institute of Mathematical Statistics and Applied Mathematics, Romanian Academy
e-mail: amm@iem.pub.ro

Mihaela Morega
Faculty of Electrical Engineering, University POLITEHNICA of Bucharest, Romania
e-mail: mihaela@iem.pub.ro

Aurora Neagoe
University of Bucharest, Romania
e-mail: 

Gelu Pașa
“Simion Stoilow” Institute of Mathematics of Romanian Academy
e-mail: Gelu.Pasa@imar.ro
Elena Pelican  
Ovidius University of Constanta, Romania  
e-mail: epelican@univ-ovidius.ro

Stefania Petra  
University of Heidelberg, Germany  
e-mail: petra@math.uni-heidelberg.de

Constantin Popa  
Ovidius University of Constanta, Romania  
Institute of Mathematical Statistics and Applied Mathematics, Romanian Academy  
e-mail: cpopa@univ-ovidius.ro

Florin Adrian Radu  
Department of Mathematics, University of Bergen, P. O. Box 7800, N-5020 Bergen, Norway  
e-mail: Florin.Radu@math.uib.no

Miroslav Rozloznik  
Institute of Computer Science, Academy of Sciences of the Czech Republic, Pod Vodarenskou vezi 2, CZ-182 07 Prague 8, Czech Republic  
e-mail: miro@cs.cas.cz

Ulrich Rüde  
University Erlangen-Nuremberg, Department of Computer Science 10, Cauerstrae 11, D-91058 Erlangen  
e-mail: Ulrich.Ruede@fau.de

Cristina Savastru  
Faculty of Electrical Engineering, University POLITEHNICA of Bucharest, Romania  
e-mail: L. Schüler  
Department Computational HydroSystems, UFZ Centre for Environmental Research, Leipzig, Germany  
e-mail: lennart.schueler@ufz.de

Christoph Schnörr  
University of Heidelberg, Image and Pattern Analysis Group, Heidelberg, Germany  
e-mail: schnoerr@math.uni-heidelberg.de

Daniel Scărădeanu  
University of Bucharest, Romania  
e-mail: Daniel.Scaradeanu@fmi.unibuc.ro

Olivian Simionescu  
Dept. of Mathematics, University of Bucharest, Romania  
e-mail: osimion@fmi.unibuc.ro

Nicolae Suciu  
Mathematics Department, Friedrich-Alexander University of Erlangen-Nuremberg, Germany  
Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy  
e-mail: suciu@math.fau.de
Miroslav Tůma  
Institute of Computer Science, Academy of Sciences of the Czech Republic  
e-mail: tuma@cs.cas.cz

Bogdan Vernescu  
Department of Mathematical Sciences, Worcester Polytechnic Institute, 100 Institute Rd., Worcester, MA 01609, USA  
e-mail: vernescu@wpi.edu

Raluca Vernic  
Ovidius University of Constanta, 124 Mamaia Blvd., 900527 Constanta, Romania  
e-mail: rvernic@univ-ovidius.ro

M. Cotrumba  
Ovidius University of Constanta, 124 Mamaia Blvd., 900527 Constanta, Romania  
e-mail:

F. Georgiadis  
e-mail:

B. Radoiu  
e-mail: