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Recent Advances in Mathematical Methods & Computational Techniques in Modern Science

Morioka City, Iwate, Japan, April 23-25, 2013

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Mathematics and Computers in Science and Engineering Series | 11

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ISSN: 2227-4588
ISBN: 978-1-61804-178-4

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Published by WSEAS Press
www.wseas.org

All papers of the present volume were peer reviewed by no less that two independent reviewers. Acceptance was granted when both reviewers' recommendations were positive.
See also: http://www.worldses.org/review/index.html

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Plenary Lecture 1

A Mathematical Model of Calcium Homeostasis: Effects of Parathyroid Hormone and Vitamin D

Associate Professor Chontita Rattanakul
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Abstract: In human, adequate amounts of calcium ion in the extracellular fluid are necessary for normal function of all cells. There are many factors involve in the maintenance of calcium homeostasis such as parathyroid hormone, vitamin D and calcitonin. A system of nonlinear differential equations is developed here in order to investigate the effects of parathyroid hormone and vitamin D on calcium homeostasis. Singular perturbation technique is then utilized to derive the conditions on the system parameters for which a periodic behavior can be assured. Numerical investigation is also carried out to support our theoretical prediction. Both theoretical and numerical results indicate that the developed model can exhibit a periodic behavior conforming to the pulsatile behavior observed clinically by many researchers in the serum levels of parathyroid hormone and vitamin D.

Brief Biography of the Speaker: Chontita Rattanakul graduated from Mahidol University, Thailand in 2003 and becoming a staff at the department of mathematics, faculty of science, Mahidol University since then. In 2004, she carried out her postdoctoral research at West Virginia University, USA under the Eiesland visiting research scholarship. Currently, she is an associate professor at the department of mathematics, faculty of science, Mahidol University and she is also the secretary of the Centre of Excellence in Mathematics, Thailand as well. Her current research interests include mathematical modeling of calcium homeostasis as well as the mechanism of bone remodeling process.

ISBN: 978-1-61804-178-4

Plenary Lecture 2

On the Spectrum of Internal Oscillations of Rotating Stratified Fluid

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Abstract: We consider mathematical properties of the three-dimensional rotating fluid in a homogeneous gravity field, which may find an application in the study of the Atmosphere and the Ocean.
In particular, we investigate the structure and localization of the spectrum of internal oscillations for differential operators generated by such flows. This spectrum may be very useful for studying the stability of the flows, since it is closely related to the non-uniqueness of the limit amplitude of the stabilized flow. Also, it is important in the investigation of weakly non-linear flows, since the bifurcation points where the small non-linear solutions arise, belong to the spectrum of linear normal oscillations.
We consider both inviscid and viscous fluid for various boundary conditions.
The novelty of this research is to consider simultaneously the effects of rotation and stratification, which has been studied separately in previous works.

Brief Biography of the Speaker: Andrei Giniatoulline received his undergraduate, MSc, and PhD degrees from Friendship University in Moscow, Russia. Since 1993, he has taught undergraduate and graduate level courses at the Department of Mathematics of Los Andes University in Bogotá, Colombia, where he holds the position of Associate Professor. His research interests are in the areas of mathematical physics, with an emphasis on hydrodynamics and applied functional analysis. He has delivered invited lectures on the subject of Spectral Theory at universities in Bolivia, Brazil, Japan, Russia, Spain and other countries.

ISBN: 978-1-61804-178-4

Plenary Lecture 3

Variable Directions Difference Scheme for One System of Nonlinear Partial Differential Equations

Professor Temur Jangveladze
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Abstract:

Mathematical modeling of many applied problems leads to following system of nonlinear partial differential equations:

$$\frac{\partial U}{\partial t} = \sum_{\alpha=1}^{p} \frac{\partial}{\partial x_\alpha} \left(V_\alpha \frac{\partial U}{\partial x_\alpha} \right), \tag{1}$$

$$\frac{\partial V_\alpha}{\partial t} = f_\alpha \left(V_\alpha, \frac{\partial U}{\partial x_\alpha} \right), \tag{2}$$

where f_α, $\alpha = 1, \ldots, p$, are given functions.

In two-dimensional case ($p = 2$) and when

$$f_\alpha \left(V_\alpha, \frac{\partial U}{\partial x_\alpha} \right) = -V_\alpha + g_\alpha \left(V_\alpha \frac{\partial U}{\partial x_\alpha} \right), \tag{3}$$
$$0 < \gamma_0 < g_\alpha(\xi_\alpha) \leq G_0,$$

where g_α are given sufficiently smooth functions and γ_0, G_0 are constants, the system (1), (2) describes the vein formation in meristematic tissues of young leaves (G.J. Mitchison, A Model for Vein Formation in Higher Plants, *Proc. R. Soc. Lond. B.* 207, 1980, pp. 79–109).

In this work and in the work J. Bell, C. Cosner and W. Bertiger, Solutions for a Flux-Dependent Diffusion Model, *SIAM J. Math. Anal.* 13, 1982, pp. 758–769, some properties of the solutions of the initial-boundary value problems for the one-dimensional and two-dimensional systems (1), (2) with (3) restrictions are established. The large theoretical and practical importance of the investigation and approximate solution of the initial-boundary value problems for multi-dimensional ($p > 1$) systems (1)-(3) is also pointed out in these works.

Naturally arises the question of constructing economical algorithms for solution of multi-dimensional problems.

At present there are some effective algorithms for solving the multi-dimensional problems. These algorithms mainly belong to the methods of splitting-up or sum approximation according to their approximative properties. It is well known that using the methods of variable directions, there arise some difficulties. Particularly, as a rule classical scheme of variable directions for three-dimensional linear parabolic equation is not absolutely stable. In the work V.N. Abrashin, A Variant of the Method of Variable Directions for the Solution of Multi-Dimensional Problems in Mathematical Physics, *Diff. Uravn.* 26, 1990, pp. 314–323 and in the number of other works as well the different kind of difference schemes belonging to the class of algorithms of variable directions are given. These schemes have some advantages. Particularly, they are absolutely stable for any p.

In the present work the investigations of one kind of such a scheme for system (1)-(3) are given. In the well known notations this scheme has the following form:

$$u_{\alpha t} = \sum_{\beta=1}^{\alpha} \left(\hat{v}_\beta \hat{u}_{\beta x_\beta} \right)_{x_\beta} + \sum_{\beta=\alpha+1}^{p} \left(v_\beta u_{\beta x_\beta} \right)_{x_\beta}, \tag{4}$$

$$v_{\alpha t} = -\hat{v}_\alpha + g_\alpha \left(v_\alpha u_{\alpha x_\alpha} \right). \tag{5}$$

The absolute stability and the convergence theorems for (4), (5) scheme are proven. We should note that in the author's previous papers and papers with his PhD students some questions of the splitting-up and average model of sum approximation for the system (1)-(3) as well as difference schemes for one-dimensional case are discussed.

ISBN: 978-1-61804-178-4

Brief Biography of the Speaker: Prof. Temur Jangveladze (Dzhangveladze) graduated from Ivane Javakhishvili Tbilisi State University, Department of Applied Mathematics and Cybernetics in 1977. He was Junior Scientific Researcher (1977-1983), Scientific Researcher (1983-1988), Senior Scientific Researcher (1988-1998), Leading Scientific Researcher (1998-present) of Ilia Vekua Institute of Applied Mathematics of Ivane Javakhishvili Tbilisi State University. Invited Assistant (1981-1984) and Invited Docent (1984-1988), Docent (1988-1998), Professor (1998-2009), Invited Professor (2009-present) at Ivane Javakhishvili Tbilisi State University. Professor at Ilia State University (2006-2010). Invited Professor (2001-2010), Professor (2010-present) at Caucasus University. Since 1977 till now Prof. T. Jangveladze gives the lectures in Numerical Analysis, Numerical Solutions of Differential Equations, Nonlinear Partial Differential and Integro-differential Models, Mathematical Modeling and etc. In 1984 he defended Ph.D. (candidate degree) thesis in specialty "Computational Mathematics". In 1998 he defended a thesis for a Doctor of Science (Habilitation) Degree in specialty "Theoretical Bases of Mathematical Modeling, Numerical Methods, Program Complexes". Field of his scientific interests is Nonlinear Differential and Integro-Differential Equations and Systems, Numerical Analysis, Nonlocal Boundary and Initial Value Problems, Mathematical Modeling and etc. The full list of his publications comprises more than 120 scientific papers and text books. He is editor and member of editorial board of several international scientific journals. He was the member of international program committee and the participant of many international scientific conferences. Prof. T. Jangveladze is a head of Department of Informatics of Tbilisi International Centre of Mathematics and Informatics (TICMI). He is chair of the Enlarged Sessions of the Seminar of Ilia Vekua Institute of Applied Mathematics, Section of Partial Differential Equations. He is holder of various national and international grant awards. Recently he has been awarded of Fulbright Visiting Scholar Program.

ISBN: 978-1-61804-178-4

Plenary Lecture 4

General Problems of the Sampling-Reconstruction Procedure of Random Field Realizations

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Abstract: There are a lot of publications devoted to a statistical description of the Sampling-Reconstruction Procedure (SRP) of random process and field realizations. Unfortunately, this problem is completely not solved until present time. This statement is especially related to the SRP of random fields because their statistical description is more difficult with comparison of random processes. Usually papers devoted to the SRP of random field realizations do not use information about the probability density function (PDF) of sampled fields. In order to overcome this principal drawback we apply the conditional mean rule (CMR) for our investigations.
We consider two different mathematical models of random fields. The first model is the Gaussian field with various types of space covariance functions. The realizations of such fields are continuous. The second model is related with fields having random jumps from one state to another. Such fields can have different number of states and their points of jumps can be described by various flows. Here the simplest case is characterized by Poison's flow. The SRP of Gaussian field realizations are shortly described by the following manner. The field is described by the multidimensional GaussianPDF. Generally this PDF describes both stationary and non-stationary fields. The non-stationary field can be characterized by changed mathematical expectation, variance and space covariance function. Besides this, we need to know the location of samples. There are some variants of location: triangular, square, pentagonal, and arbitrary. Applying the CMR we obtain the optimal reconstruction surface and the error reconstructionsurface. The SRP of Gaussian field realizationsare completely described by these two surfaces.
The SRP of fields with jumps is investigated by another methodology. In fact, such fields are characterized not only by their covariance functions. Here it is necessary to have a description of locations of random jump pointsin the field. The simple variant of a mathematical model of such field if related with Markov binary processes determined along of both axes. In this case we have a model like chess board with random rectangles. If we fix some functions of the Markov binary process realizations along the both axes then we can have the field with four possible states. Besides this we need to know the location of samples. Once again, using CMR for the estimation of jump points one can describe the surface reconstruction and the error reconstruction surface. Results of proposed investigations have a practical application in two variants: 1) if we know the description of field and the location of samples, then one can obtain reconstruction surface and the error reconstruction surface; 2) if we have a required value of the error reconstruction surface, one can find acceptable intervals between samples along both axes; besides this we can find reconstruction surface and the error reconstruction surface.

Brief Biography of the Speaker: Vladimir Kazakov was born in Moscow region in Russia in 1941. He received the Ph. D. degree in 1967 and the Full Doctor of Science degree in 1990 from Moscow Power Engineering Institute (Technical University). During 1966 – 1996 he worked in Ryazan Radio Engineering University. Since 1996 until the present time he has worked in the National Polytechnic Institute of México. His principal research interests lie in the statistical communication theory. He is the author of more than 200 scientific publications, among of them 3 books, 4 chapters of books, more than 50 papers in the International Journals,17 patents of Russia and 2 patents of Mexico.

ISBN: 978-1-61804-178-4

Plenary Lecture 5

Problems of Social Business Information System and a Solution Proposal

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Abstract: Industrial business information systems like a bankingsystem, ERP, SCM have grown as a big software business in Japan. But now,their main partsbecome maintenance works.On the other side,social business information systems such as medical healthcare, environment, education and regional community are rapidly growing according toincreasing social demands.This social business area is mainly a target of mediumsize software companies.In this area, three kinds of hard problems exist. The first is a great gap between strategic goals of user companies and objectives of information systems such as quality, cost anddelivery.Secondly, there is difficulty to integrate the software functionsdeprived from requirement specificationsand the functions of installed system components like smart phone,tablets, robots and sensors. As a result, this difficulty brings about a large man-month cost and increase software defects.
Thirdly, end users in this area are not professionals,but mainly novices. Their skills to utilize new information systems are comparatively low.Therefore, it takes more cost and time to improve their ITliteracy.
I first propose that we must build up a new value chain between the business strategic goals and the objectives ofinformation systems. Secondly, it is necessary to develop a new methodology for systematic management of every functionalinteraction between the system components and applicationsoftware.At last, higher interoperability among systemcomponentsare needed in order to enhance user interface usability.

Brief Biography of the Speaker: Yutaka Funyu graduated from Department of Electronics,Tohoku University in 1962. During 1962-1998 he worked in JFE(KawasakiSteel Corp.),CSKand Yokogawa Electric Corp.He received Ph.D. degree from Tohoku University in 1987.He was a professorof Faculty of Information and Software Science, Iwate Prefectual University(IPU)during 1998-2008,and vice president also during 2006-2008.He is now a professor emeritus of IPU and CEO of Software CollaborationResearch Institute.His main research area is information system developmentand software engineering.

ISBN: 978-1-61804-178-4

Plenary Lecture 6

Managing Software and Enterprise Complexity

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Abstract: Studies show that software development, integration, and implementation within a manufacturing enterpriseface complex organisational, technical, and social shortcomings. As a result of these shortcomings, business reengineering projects often fail due to the enormous gap between the IT infrastructure and the corresponding demands of the new processes. Enterprise complexity includes issues such as inflexible, centralized, and monolithic system architectures, inherent instable processes, mixture of continuous and batch operations, incomplete and/or excessive data, changed processes, or temporal problems. However, in addition to these, many times, software systems in the real world wereconsidered large and complex and the IT architecture didn't reduce application complexity and provide its required flexibility.Therefore, the purpose of this plenary lecture is to explore how the complexity of both software and enterprise can be effectively and successfully managed.Based on the research's qualitative findings supported by authorities, evidence, or logic, essentially, it is argued that thearchitecture of a new software system should be aligned with the manufacturing system structure, its characteristics, the new technologies, and that the use the wisdom of simplicity in order to control complexity should prevail against the attempt to develop complex systems that usually are a consequence of unnecessary requirements.This exploration also leads to the need for an enterprise informationarchitecture framework for problem solving that should be aligned with the business practices and the ways in which the companies are run, and which finally leads to a system of systems which is architectural-centric, process-centric, human-centric, and in line with the IT infrastructure trends.

Brief Biography of the Speaker: Ionel Botef graduated in 1977 from the Polytechnic Institute of Bucharest, Romania, with a Masters in Mechanical and Manufacturing Engineering. In the 1980s he worked as a senior engineer with Turbomecanica, a manufacturer of aircraft engines, wherehe coordinated the technology for SPEY 512-14 DW aircraft engine, a cooperation programme with Rolls-Royce, UK. In the 1990s he moved to South Africa where he achieved his PhD from the Electrical and Information Engineering, University of the Witwatersrand, Johannesburg. From 1998 he has been a full time academic with the School of Mechanical, Industrial, and Aeronautical Engineering, University of the Witwatersrand, Johannesburg.His research interests focus on interdisciplinary research that include company integration, information systems, manufacturing processes and systems, materials science, software engineering, complex systems, and computational techniques.

ISBN: 978-1-61804-178-4

Plenary Lecture 7

C# Based EEG Encryption System Using Chaos Algorithm

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Abstract: In the presentation, we discuss Microsoft's Visual Studio Development Kit and the C# programming language to implement chaos-based electroencephalogram (EEG) encryption system with three encryption levels. A chaos logic map, an initial value, and a bifurcation parameter for the map are used to generate level I chaos-based EEG encryption bit streams. Two encryption-level parameters are added to these elements to generate level II chaos-based EEG encryption bit streams. An additional chaotic map and a chaotic address index assignment process are added to implement level III chaos-based EEG encryption system. Eight 16-channel EEG Vue signals are tested using the encryption software. The encryption speed is the lowest, and encryption is most robust for the level III system. The test results show that the results of encryption are superior, and when the correct deciphering parameter is applied, the EEG signals are completely recovered. However, an input parameter error, for example, a 0.00001% initial point error, will cause chaotic encryption bit streams, and 16-channel EEG Vue signals will not be recovered. The authors acknowledge the support of the NSC 100-2221-E-019-019, and NSC 101-2221-E-019-056.

Brief Biography of the Speaker: Dr. Chin-Feng Lin was born in Taiwan, in 1974. He received the B.S. degree in electrical engineering from Chung-Yung University in 1996 and the M.S. degree in electrical engineering from Chung-Hua University in 1998. He received the Ph.D. degrees in Commuincation Engineering from National Chiao Tung University, Taiwan, in 2002. Afterwards, he served as an assistant professor since 2004 in the Department of Electrical Engineering at National Taiwan Ocean University. He has been published 23 journal papers, one English online book, 4 English book chapters, 5 Chinese books, 8 Chinese patents, and 61 conference papers. His research interests include mobile telemedicine, biomedical signal processing, and underwater multimedia communication. He is a WSEAS member.

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ISBN: 978-1-61804-178-4