*Editors*

Dalibor Biolek

N. A. Baykara

# Advances in Systems Theory, Signal Processing & Computational Science

Proceedings of the 12th WSEAS International Conference on Signal Processing, Computational Geometry and Artificial Vision (ISCGAV '12)

Proceedings of the 12th WSEAS International Conference on Systems Theory and Scientific Computation (ISTASC '12)

Istanbul, Turkey, August 21-23, 2012

Recent Advances in Electrical Engineering Series | 5

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**Preface**

This year the 12th WSEAS International Conference on Signal Processing, Computational Geometry and Artificial Vision (ISCGAV '12) and the 12th WSEAS International Conference on Systems Theory and Scientific Computation (ISTASC '12) were held in Istanbul, Turkey, August 21-23, 2012. The conferences provided a platform to discuss nonlinear signals and systems, broadband audio coding, multidimensional systems, machine vision, image coding, remote sensing, dynamical systems and chaos, scientific computation, distributed computing, finite elements, heuristic algorithms, cryptology, communication protocols etc. with participants from all over the world, both from academia and from industry.

Their success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The accepted papers of these conferences are published in this Book that will be sent to international indexes. They will be also available in the E-Library of the WSEAS. Extended versions of the best papers will be promoted to many Journals for further evaluation.

Conferences such as these can only succeed as a team effort, so the Editors want to thank the International Scientific Committee and the Reviewers for their excellent work in reviewing the papers as well as their invaluable input and advice.

The Editors

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## Keynote Lecture 1

# Singing in the Magic Empire of Stars: Probabilistic Evolution Approach to Celestial Mechanical Problems

**Professor Metin Demiralp**
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**Abstract:** Many problems of Celestial Mechanics are not analytically solvable until now even though there have been many attempts and developments for numerical solutions to this end. Perhaps the mathematically speaking the most important problem has been the three body problem whose certain solutions were given under certain specific restrictions while series solutions like Unsold's expansion and perturbation expansion proposed by Poincare were made available some time ago. We are going to focus on the three particle problem in this talk. The issue is just to obtain the governing ODEs and initial conditions and then try to construct the solution. This is very well known and available almost everywhere. However, the governing equations are quite nonlinear and singular making the construction of an analytic solution almost impossible. The series solutions have slow numerical convergence problems and certain accelerating methods can be used to cure this situation. Nevertheless many well-developed approximating techniques are available.
The basic reason making the problem almost unsolvable is the nonlinearity. On the other hand we have recently developed a new method to solve any kind of explicit ODE or ODE system accompanied by certain compatible conditions by using a basis set expansion in the space where the unknown solution of the equations lie. We called this approach "Probabilistic Evolution Approach" which produces a denumerably infinite number of ODEs and accompanying conditions which are called "Probabilistic Evolution Equations (PEEs)". PEEs can be written in a single first order linear and homogeneous infinite vector ODE whose denumerably-infinite-element coefficient matrix is constant (we call it "Evolution Matrix due to basic characteristics of the solution it possesses).
The important issues are autonomy, triangularity and the conicality in the Evolution Matrix and they may not arise unless the structure of the descriptive functions appearing as right hand side functions in the original ODE(s) permit. This nonexistence can be converted to existence by using space extension via new appropriate unknown definitions. These extensions work well in the three particle problem of celestial mechanics and new equations can be constructed such that the descriptive functions are conical and vanish at certain points of the extended space. Talk will focus on these issues within the time limitations.

**Brief Biography of the Speaker:** Metin Demiralp was born in T¨urkiye (Turkey) on 4 May 1948. His education from elementary school to university was entirely in Turkey. He got his BS, MS degrees and PhD from the same institution, ˙Istanbul Technical University. He was originally chemical engineer, however, through theoretical chemistry, applied mathematics, and computational science years he was mostly working on methodology for computational sciences and he is continuing to do so. He has a group (Group for Science and Methods of Computing) in Informatics Institute of ˙Istanbul Technical University (he is the founder of this institute).
He collaborated with the Prof. Herschel A. Rabitz's group at Princeton University (NJ, USA) at summer and winter semester breaks during the period 1985–2003 after his 14 month long postdoctoral visit to the same group in 1979–1980. He was also (and still is) in collaboration with a neuroscience group at the Psychology Department in the University of Michigan at Ann Arbour in last three years (with certain publications in journals and proceedings).
Metin Demiralp has more than 90 papers in well known and prestigious scientific journals, and, more than 200 contributions to the proceedings of various international conferences. He gave many invited talks in various prestigious scientific meetings and academic institutions. He has a good scientific reputation in his country and he is one of the principal members of Turkish Academy of Sciences since 1994. He is also a member of European Mathematical Society. He has also two important awards of turkish scientific establishments.
The important recent foci in research areas of Metin Demiralp can be roughly listed as follows: Probabilistic Evolution Method in Explicit ODE Solutions and in Quantum and Liouville Mechanics, Fluctuation Expansions in Matrix Representations, High Dimensional Model Representations, Space Extension Methods, Data Processing via Multivariate Analytical Tools, Multivariate Numerical Integration via New Efficient Approaches, Matrix Decompositions, Multiway Array Decompositions, Enhanced Multivariate Product Representations, Quantum Optimal Control.

## Plenary Lecture 1

# Nonlinear Tracking: The Approach Based on Extended Kalman-Like UFIR Filtering

**Professor Yuriy S. Shmaliy**
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DICIS, Guanajuato University
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**Abstract:** Tracking of moving objects is often provided employing the first-order and sometimes the second-order extended Kalman filters. The problem we meet here is associated with the process noise covariance which cannot always be specified correctly and also with the model temporary uncertainties. In this lecture, we show that an efficient remedy against these problems is unbiased averaging associated with finite impulse response (FIR) filtering. For suboptimal nonlinear tracking in discrete-time state-space with additive white noise, we accordingly derive and discuss the first- and second-order extended Kalman-like unbiased FIR filters (EFIR1 and EFIR2, respectively). Unlike the extended Kalman filter (EKF), the EFIR1 one does not require noise covariances and initial errors. By virtue of this, it demonstrates better robustness against temporary uncertainties in real world. Only within a narrow region around an actual process noise covariance, the EFIR filter falls a bit short of EKF and it demonstrates better performance otherwise. We show that the optimal averaging interval for EFIR filters can be determined via measurement in a "learning" circle and then re-determined and updated whenever necessary. We also notice that the second-order approximation can improve the local performance, but it can also deteriorate it. Thus, there can be given no definitive recommendations about its use, at least for tracking problems.

**Brief Biography of the Speaker:** Dr. Yuriy S. Shmaliy is Full Professor in Electrical Engineering of the University of Guanajuato, Mexico, since 1999. He received the B.S., M.S., and Ph.D. degrees in 1974, 1976 and 1982, respectively, from the Kharkiv Aviation Institute, Ukraine. In 1992 he received the Dr.Sc. degree from the Soviet Union Government. In March 1985, he joined the Kharkiv Military University. He serves as Full Professor beginning in 1986 and has a certificate of Professor from the Ukrainian Government in 1993. In 1993, he founded and, by 2001, had been a director of the Scientific Center "Sichron" (Kharkiv, Ukraine) working in the field of precise time and frequency. His books Continuous-Time Signals (2006) and Continuous-Time Systems (2007) were published by Springer, New York. His book GPS-based Optimal FIR Filtering of Clock Models (2009) was published by Nova Science Publ., New York. He also edited a book Probability: Interpretation, Theory and Applications (Nova Science Publ., New York, 2012) and contributed to several books with invited chapters. Dr. Shmaliy has 292 Journal and Conference papers and 80 patents. He is IEEE Fellow; was rewarded a title, Honorary Radio Engineer of the USSR, in 1991; was listed in Marquis Who's Who in the World in 1998; was listed in Outstanding People of the 20th Century, Cambridge, England in 1999; and was listed in The Contemporary Who's Who, American Bibliographical Institute, 2003. He is currently an Associate Editor for Recent Patents on Space Technology. He serves on the Editorial Boards of several International Journals and is a member of the Organizing and Program Committees of various Int. Symposia. His current interests include statistical signal processing, optimal estimation, and stochastic system theory.

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## Plenary Lecture 2

# Efficient Compression of Sequences of Medical Images

**Professor Roumen Kountchev**
Technical Univerity of Sofia
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Faculty of Telecommunications
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**Abstract:** The plenary speech will be devoted to one new approach for compression of sequences of medical images obtained from medical scanners, based on the Inverse Pyramid Decomposition. Similar idea is used for the efficient archiving of multispectral (satellite) images, which uses special adaptation of the method. The new approach is based on joint processing of the sequence of images as a group, representing the same object, and obtained after time intervals. The background of the new approach is the use of the Inverse Pyramid Decomposition, which performs leveled image representation with increasing quality of the approximations obtained in the consecutive decomposition levels, together with histogram matching to one of the images, selected to be used as a reference one. The coarsest approximation of the reference image is used to calculate the next (better) approximations of the remaining images in the group. As a result, is obtained efficient compression of the processed groups of images, which is of high importance for their archiving and storage in image databases. Numerous experiences were performed with medical and satellite images, which proved the method efficiency.

**Brief Biography of the Speaker:** Prof. Kountchev graduated from the Technical University of Sofia (M. Sc., Electronics) and got his PhD degree at the Institute of Telecommunications, St. Petersburg, Russia. His PhD thesis was ”Digital Methods for Structure Analysis of the Objects in the Image”. The second thesis of Prof. Kountchev was on ” Inverse Pyramidal Image Decomposition: Methods and Algorithms” and it was successfully defended at the Technical University of Sofia. From 2003 he is Professor at the Technical University of Sofia. His main research interests are in image processing, image compression, invariant object representation, neural networks, image watermarking, object search in image databases, etc. He had already published 20 textbooks and invited book chapters, 291papers in proceedings of international scientific conferences and magazines, and has 20 international patents. He is the President of the Bulgarian Association for Pattern Recognition (BAPR), and is a member of the International Association for Pattern Recognition (IAPR), from 1999.

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## Plenary Lecture 3

# Improvement of the Power Quality Indicators in Functioning of Nonlinear Loads Using LabVIEW

**Assistant Professor Caius Panoiu**
Electrical Engineering and Industrial Informatics Department
Engineering Faculty of Hunedoara
Politehnica University of Timisoara, Romania
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**Abstract:** Power electronic converters represent one of the most important components that cause harmonic distortion in the power distribution. Distortion regime produces negative effects in functioning of other electric energy consumers. Distorting consumers absorb from the power system active and reactive powers on the 1st order component more then necessity, the difference being returned to the power supply system as distorted power. In linear power supply system the power loss are determined by the active and reactive powers circulation produced by system generators and also by the distorting powers circulation produced by the nonlinear loads. For compensating this negative impact, there must be connected power conditioning devices at the interface with the power supply system in order to obtain improvements in power quality indicators. This paper describes the LabVIEW implementation for a three phase active filter command system. The main purpose of this active filter is compensation of the current harmonics in power supply system generated by an electro thermal installation with electromagnetic induction. Filtering system acquires distorted current and voltage signals from the power supply system using a signal acquisition interface and a data acquisition board connected to a computer. The main function of the interface is to realize the compatibility between voltage levels of the acquired signals and also the data acquisition board requirements. Another condition that must be accomplished is the galvanic isolation between power supply system and data acquisition board. Using an application designed in LabVIEW, the ddistorted signals are acquired and saved into text documents in order to be processed. The application also realizes the pulse width modulation operation of the distorted signals. The resulting pulses command the active filter switching devices using the pin outs of same data acquisition board. The paper also presents the variation of the generated command pulses during the functioning of the electro thermal installation.

**Brief Biography of the Speaker:** Caius Panoiu was born in 1965 and graduates in 1989 the Faculty of Electronics and Telecommunications, 'Politehnica' University of Timisoara. He receives his PhD in Electrical Engineering in 2001 at 'Politehnica' University of Timisoara and currently is Assistant Professor at the Electrical Engineering and Industrial Informatics Department of Engineering Faculty of Hunedoara, 'Politehnica' University of Timisoara, Romania. The research interests of Caius Panoiu are focused on signal processing, modeling and simulating systems and data acquisition. He is author or co-author of over 100 research papers that are published in journals and conferences and participates to 10 research projects.

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## Plenary Lecture 4

# Speech Enhancement Using Bone Conducted Speech

**Professor Tetsuya Shimamura**
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**Abstract:** Speech enhancement techniques are often required in speech processing applications like hands-free communications, hearing aids and speech recognition. During the past few decades, significant progress has been made in the development of speech enhancement algorithms capable of reducing noise. Unfortunately, such noise reduction methods often introduce distortion and the intelligibility is sometimes degraded in severely noisy environments. In this plenary speech, as an old but new technique for speech enhancement, bone-conducted speech is used. The transmission of voice on bones is called bone conduction. When the voice waveforms are transmitted from the voice source (vocal cord) through the vocal tract wall and skull, they do not confront directly with noise. This is the reason why the bone-conducted speech signal can be utilized in a very noisy environment. However, normally it is known that the quality of bone-conducted speech is comparatively lower than that of normal speech being transmitted through air. This may be caused by the fact that the frequency components more than 1[kHz] deteriorate in bone-conducted speech. A straightforward method to improve the quality of bone-conducted speech is to emphasize the high frequency components. However, this has been not accepted in many cases. One of the reasons of this fact may be that the phenomenon of bone conduction is speaker dependent. Thus, in this plenary speech, as a speaker-dependent technique, the use of an air- and bone-conduction integrated microphone is mainly discussed. Also, it is presented that the quality of bone-conducted speech can be significantly improved by combining adequately both the normal and bone-conducted speech signals. The goal of this kind of research is to obtain a clean speech signal in highly noisy environments.

**Brief Biography of the Speaker:** Tetsuya Shimamura received the B.E., M.E., and Ph. D. degrees in electrical engineering from Keio University, Yokohama, Japan, in 1986, 1988, and 1991, respectively. In 1991, he joined Saitama University, Saitama City, Japan, where he is currently a Professor. During this, he joined Loughborough University, UK, and The Queen's University of Belfast, UK, in 1995 and 1996, respectively, as a visiting Professor. He is an author or co-author of 6 books, and member of the organizing committee of several international conferences. His interests are in digital signal processing and its applications to speech, image and communication systems. He received a Gold Paper Award at IEEE Pacific Rim Conference on Communications, Computers and Signal Processing in 2011.

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## Plenary Lecture 5

# A Wavelet Based Approach for Image Reconstruction from Gradient Data and its Applications

**Professor Pan Agathoklis**
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**Abstract:** There are many applications where a 2-D function has to be obtained by numerically integrating gradient data measurements. In signal and image processing, such applications include rendering high dynamic range images on conventional displays, editing and creating special effects, as well as possible future digital photography where the cmera is sensing changes in intensity instead of intensity as it is the case in most cameras today. A common approach to deal with this 2-D numerical integration problem is to formulate it as a solution of a 2D Poisson equation and obtain the optimal least-squares solution using any of the available Poisson solvers. An alternative is to convert the surface normals to equivalent 2-D gradient data and solve this problem by a Fourier transform based integration method. Another area of application is in adaptive optics telescopes where wave front sensors provide the gradient of the wave front and it is required to estimate it by essentially integrating the gradient data. Several fast methods have been developed to accomplish this, such as the Multigrid Conjugate Gradient and Fourier transform techniques similar to those used in computer vision. Recently, a new reconstruction method based on wavelets has been developed and applied to image reconstruction for adaptive optics. This method is based on obtaining a Haar wavelet decomposition of the image directly from the gradient data and then using the well known Haar synthesis algorithm to reconstruct the image. This technique further allows the use of an iterative Poisson Solver at each resolution to enhance the visual quality of the resulting image. This talk focuses on image reconstruction techniques from gradient data and discusses the various areas where these techniques can be applied.

**Brief Biography of the Speaker:** Pan Agathoklis received the Dipl. Ing. degree in electrical engineering and the Dr. sc. techn. degree from the Swiss Federal Institute of Technology, Zurich, Switzerland, in 1975 and 1980, respectively. From 1981 until 1983, he was with the University of Calgary as a Post-Doctoral Fellow and part-time Instructor. Since 1983, he has been with the Department of Electrical and Computer Engineering, University of Victoria, B.C., Canada, where he is currently a Professor. He has received a NSERC University Research Fellowship and Visiting Fellowships from the Swiss Federal Institute of Technology, from the Australian National University and the University of Perth, Australia. He was Associate Editor for the IEEE Transactions on Circuits and Systems in 1990-1993 and he is currently Associate Editor for Multidimensional Systems and Signal Processing, CSSP and Journal of Electrical and Computer Engineering He has been member of the Technical Program Committee of many international conferences and has served as the Technical Program Chair of the 1991 IEEE PACRIM Conference the 1998 IEEE Symposium on Advances in Digital Filtering and Signal Processing and the 2009 ISSPIT. His fields of interest are in control, digital signal processing and their applications. He worked in the stability of multidimensional systems and in the application of 2D and 3D filtering in radio astronomy for removing radio interference. His interest in adaptive optics and its application in the development of optical telescopes lead to new solutions to the problem of image reconstruction from gradient data. These results are also being applied to problems in image processing like Poisson Editing, image stitching etc.

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## Plenary Lecture 6

# Singular Perturbations and Time Scales (SPaTS) in Control Theory and Applications

**Professor D. Subbaram Naidu**
Measurement and Control Engineering Research Center
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**Abstract:** An overview of the author's journey of research experience in Singular Perturbations and Time Scales (SPaTS) in Control Theory and Applications (CTA) from 1965 at Indian Institute of Technology (IIT), to 2012 at Idaho State University (ISU) is presented. The SPaTS methodologies focus on the analysis of decoupling of high-order dynamical systems with slow and fast phenomena and the synthesis (design) of controllers for slow and fast subsystems. The research covers both theory and applications to a wide spectrum of fields in engineering such as aerospace, electrical, mechanical, and in sciences such as biology and ecology and the presentation is based on the author's books, survey articles and some recent results.

**Brief Biography of the Speaker:** Desineni "Subbaram" Naidu received MTech and PhD degrees in Electrical Engineering (Control Systems Engineering), from Indian Institute of Technology (IIT), Kharagpur. Dr. Naidu taught, visited and/or conducted research at IIT; Guidance and Control Division at NASA Langley Research Center; Old Domain University; Center of Excellence in Advanced Flight Research at United States (US) Air Force Research Laboratory; Center of Excellence for Ships and Ocean Structures at Norwegian University of Science and Technology; Measurement and Control Laboratory at Swiss Federal Institute of Technology; Nantong University, China; the University of Western Australia in Perth, Center for Industrial and Applied Mathematics at the University of South Australia in Adelaide; Jiangsu College of Information Technology, Jiangsu, China; Center for Applied and Interdisciplinary Mathematics at East China Normal University, Shanghai, China; Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, China; Shanghai Jiao-Tong University, Shanghai, China. Since 1990, Professor Naidu has been with Idaho State University, where he is Director of School of Engineering and Director of Measurement and Control Engineering Research Center. Professor Naidu received twice the Senior National Research Council Associateship award from the US National Academy of Sciences, and is an elected Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and an elected Fellow of the World Innovation Foundation, UK. He has over 200 journal and conference publications including 6 books. He has been on the editorial boards of several journals including the IEEE Transactions on Automatic Control and Optimal Control: Applications and Methods.

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## Plenary Lecture 7

# High Precision Positioning Control System for a Nano Micro Manipulators Platform

**Professor Luige Vladareanu**
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**Abstract:** The paper presents a real time control system for high precision positioning of a 4 nano micro manipulators platform in order to increase the positioning precision at high speed through reducing and compensating dynamic vibrations induced by the system's movement. The control system, based on the system dynamic inversion method, ensures a desired trajectory with a fast mitigation of the vibrations by introducing an active damping force computation, having as input signals velocity, position and in some cases force. Through determining the optimal trajectory, using a quadratic cost function for reducing tracking errors, there results a six fold increase in tracking speed on micro or nano-metric positioning precision. The robot control system with compliant wrist allows for the control of the hybrid position and force in Cartezian coordinates through real time processing of the Jacobine matrix obtained out of the forward kinematics using the Denevit-Hartenberg method and calculating the Jacobine inverted matrix for control in closed loop. Also, a new method for determining the control error is proposed consisting of a fuzzy multi-stage control on three different decision stages in order to determine the movement velocity. That implies the realization of three fuzzy control loops: one in position, one in force and the other in structural vibrations. The control systems allows for practically eliminating jamming and vibrations, having a fast response of the control loop. Finally, the system's performance will allow the introduction of new functions without significant change to the hardware and through an overwhelming contribution of knowledge in developing supplementary functions for a 4 nano-micro manipulators platform: nano-metric positioning, reducing structural vibrations, with direct application in nano-micro manufacturing.

**Brief Biography of the Speaker:** Luige Vladareanu received his M.Sc. degree in electronics from the Polytechnic Institute Bucharest, in 1977. From 1984, scientific researcher of the Institute of Physics and Material Technology, from 1990, team leader of data acquisition systems and real time control systems of the Institute of Solid Mechanics, from 1991, President General Manager of Engineering and Technology Industrial VTC Company. In 1998 he received Ph.D. degree in electronics field from the Institute of Solid Mechanics of Romanian Academy. From 2003, Ministry of Education and Research, executive Department for Financing Superior Education and of Scientific University Research - High Level Expert Consulting for MEC/CNCSIS project, from 2003-2005, member of Engineering Science Committee of Romanian National Research Council, from 2005, Scientific Researcher Gr.I (Professor) of Romanian Academy, from 2009 Head of Robotics and Mechatronics Department of Institute of Solid Mechanics, Romanian Academy. His scientific work is focused on real time control in solid mechanics applied in robot trajectory control, hybrid position – force control, multi-microprocessor systems for robot control, acquisition and processing of experimental physical data, experimental methods and signal processing, nano-micro manipulators, semi-active control of mechanical system vibrations, semi-active control of magnetorheological dissipaters systems, complex industrial automations with programmable logical controllers in distributed and decentralized structure. He has published 4 books, over 20 book chapters, 11 edited books, over 200 papers in journals, proceedings and conferences in the areas. Director and coordinator of 7 grants of national research – development programs in the last 5 years, 15 invention patents, developing 17 advanced work methods resulting from applicative research activities and more then 60 research projects. In 1985 the Central Institute of Physics Bucharest awarded his research team a price for the first Romanian industrial painting robot. He is the winner of the two Prize and Gold of Excellence in Research 2000, SIR 2000, of the Romanian Government and the Agency for Science, Technology and Innovation. 9 International Invention and Innovation Competition Awards and Gold of World's Exhibition of Inventions, Geneva 2007 - 2009, and other 9 International Invention Awards and Gold of the Brussels, Zagreb, Bucharest International Exhibition. He received "Traian Vuia" (2006) award of the Romanian Academy, Romania's highest scientific research forum, for a group of scientific papers published in the real time control in the solid mechanics. He is team leader of two ANCS (Scientific Research National Agency) funded research projects: "Fundamental and Applied Researches for Position Control of HFPC MERO Walking Robots" from CNCSIS-Exploratory Researches Program and "Complex Modular Automation Systems for Technological Flux Control AUTMPG" from AMCSIT-Innovation Program. He is a member of the International Institute of Acoustics and Vibration (IIAV), Auburn University, USA (2006), ABI´s Research Board of Advisors, American Biographical Institute (2006), World Scientific and Engineering Academy Society, WSEAS (2005), International Association for Modelling and Simulation Techniques in Enterprises-AMSE, France (2004), National Research Council from Romania(2003-2005), etc. He is a PhD advisor in the field of mechanical engineering at the Romanian Academy. He was an organizer of several international conferences such as the General Chair of four WSEAS International Conferences (http://www.wseas.org/conferences/ 2008/romania/amta/index.html), chaired Plenary Lectures to Houston 2009, Harvard, Boston 2010 and Penang, Malaysia 2010, Paris 2011 to the WSEAS International Conferences, is team leader of WSEAS scientific research project: Mechanics & Robotics Systems and is serving on various other conferences and academic societies.

## Plenary Lecture 8

# New HDMR Based Methods for Multivariate Data Modelling

**Assist. Prof. M. Alper Tunga**
Bahcesehir University
Faculty of Engineering
Software Engineering Department
Istanbul, TURKIYE (TURKEY)
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**Abstract:** High Dimensional Model Representation (HDMR), which was first proposed by Sobol in 1993, is a divide-and-conquer method with a finite expansion. This expansion has a constant value, a summation on some univariate functions, another summation on some bivariate functions and so on. There are totally $2^N$ components in this expansion where $N$ is the number of independent variables or parameters of the given multivariate problem. The HDMR method is used to represent a given multivariate function in terms of less variate functions to reduce the mathematical and computational complexity coming from multivariance in especially the computer based applications. For instance, using only the constant value and the summation of univariate functions, a univariate approximation can be obtained to represent the given multivariate function through HDMR. The determi- nation process of each component appearing in the HDMR expansion includes multituple integrals under a product type multivariate weight function.
In multivariate data modelling problems, the nodes with the associated function values are given and it is asked to construct a model to be able to estimate the function value of any node whose function value is unknown. A product type weight need in HDMR algorithm results in an orthogonal geometry prerequisite in the data structure of the given problem. However, a data modelling problem usually has a multivariate training data set which includes a number of arbitrarily distributed points with the associated function values. The function values at all possible nodes of the problem domain cannot be known which means that we cannot use a product type weight in HDMR for modelling this type of problems. In addition, we know that if we would have an orthogonal geometry in the given multivariate data set, then the approximation obtained for the given problem becomes of the highest quality.
The Indexing HDMR methods transform the given problem space having a nonorthog- onal geometry to an index space which has an orthogonal structure and model the index space instead of original. This gives us the flexibility of using the HDMR philosophy with a product type weight and since we are dealing with modelling data, a Dirac delta type weight best fits our purpose. This talk will cover the details of the Indexing HDMR Method and the Matrix based Indexing Method which are developed to construct a model for a given multivariate data modelling problem.

**Brief Biography of the Speaker:** M. Alper TUNGA was born in ˙Istanbul, Turkey on 11th June 1975. He received a B.Sc. degree in Mathematics Engineering from Istanbul Technical University (I.T.U.) in 1997. He got his M.Sc. degree in Systems Analysis from ˙Istanbul Technical University in 1999. He got a PhD from Istanbul Technical University in 2006 with a thesis entitled “Data Partitioning and Multivariate Interpolation via Various High Dimensional Model Representations ”. In 1998, he worked as a research assistant in Computational Science and Engineering Department of I.T.U. Between the years 1999-2006 he worked as a research assistant in the Computer Engineering Department of Isık University of Turkey. Since 2007, he is Assistant Professor in Bahcesehir University. He is also a member of Group for Science and Methods of Computing in Informatics Institute of Istanbul Technical University. He is working on methodology for computational sciences. His interests are HDMR, multivariate data modelling and data mining. M. Alper Tunga has 12 papers about these subjects in various scientific journals.

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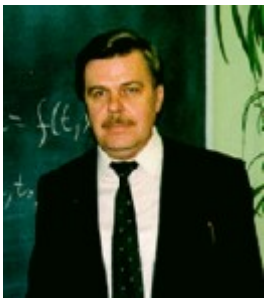
## Plenary Lecture 9

# Limit Cycles in Two-Dimensional Quadratic Systems: Analytical Methods and Visualization



**Professor Gennady A. Leonov**
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**Abstract:** The study of limit cycles of two-dimensional dynamical systems was stimulated by purely mathematical problems (the center-and-focus problem, Hilbert's sixteenth problem, and isochronous centers problem) as well as many applied problems (the oscillations of electronic generators and electrical machines, the dynamics of populations). In 1901 Hilbert, in his famous 16-th problem, posed a problem of the analysis of relative disposition and the number of limit cycles for two-dimensional polynomial systems. At the present time there exist different methods for "construction" of limit cycles. For a more than century history, in the framework of the solution of this problem the numerous theoretical and numerical results were obtained. But the problem is still far from being resolved even for the class of quadratic systems The appearance of modern computers permits one to use numerical simulation of complicated nonlinear dynamical systems and to obtain new information on the structure of their trajectories. However the possibilities of "simple" approach, based on the construction of trajectories by numerical integration of the considered differential equations, turned out to be highly limited. Academician V.I Arnol'd writes in his book: "To estimate the number of limit cycles of square vector fields on plane, A.N. Kolmogorov had distributed several hundreds of such fields (with randomly chosen coefficients of quadratic expressions) among a few hundreds of students of Mechanics and Mathematics Faculty of Moscow State University as a mathematical practice. Each student had to find the number of limit cycles of a field. The result of this experiment was absolutely unexpected: not a single field had a limit cycle! It is known that a limit cycle persists under a small change of field coefficients. Therefore, the systems with one, two, three (and even, as has become known later, four) limit cycles form an open set in the space of coefficients, and so for a random choice of polynomial coefficients, the probability of hitting in it is positive. The fact that this did not occur suggests that the above-mentioned probabilities are, apparently, small." In this lecture the effective analytical and numerical method for investigation and visualization of limit cycles will be discussed.

**Brief Biography of the Speaker:** Gennady A. Leonov received his PhD (Candidate Degree) in mathematical cybernetics from Saint-Petersburg State University in 1971 and Dr.Sci. in 1983. From 1985 – he is full professor at the Mathematics and Mechanics Faculty. He has been vice-rector of Saint-Petersburg State University from 1986 to 1988. Now Gennady A. Leonov is Dean of Mathematics and Mechanics Faculty (since 1988), Director of Research Institute of Mathematics and Mechanics of St.-Petersburg State University (since 2004), Head of Applied cybernetics Department (since 2007). Professor G.A. Leonov authored and co-authored 300 books and papers. His research interests, now in qualitative theory of dynamical systems, stabilization, nonlinear analysis of phase synchronization systems and electrical machines.

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## Plenary Lecture 10

# On the Transformational HDMR Method

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**Abstract:** High Dimensional Model Representation Method (HDMR) is a divide and con quer technique originally suggested by I.M. Sobol later developed by H. Rabitz and M. Demiralp. Various requirements urged these authors as well as others to develop different versions of HDMR. Some of these like Cut HDMR, Mul ticut HDMR, Random Sampling HDMR etc. were suggested for tackling with large numbers of data processing. Such HDMR versions however, will be out of the scope of this talk. An alternative route was dealing with functions of multiplicative nature rather than of additive nature. To this end Demiralp's group developed HDMR versions like Factorized HDMR, Hybrid HDMR and Logarithmic HDMR. The last of these, is based on the idea of transforming a function of multiplicative nature to one of additive nature simply by taking its logarithm. Applying the standard (i.e. Plain) HDMR to this newly obtained function, HDMR components are obtained. This is followed by exponentia tion of HDMR components. It was the fundamental idea behind Logarithmic HDMR which led to the possibility of using alternative transformations and inverse transformations. As a result the more general idea of Transformational HDMR was suggested again by the Demiralp group. Transformational HDMR has been used to develop new approximations of various functions. To this end Rational as well as Conical and Mobius Transformations were used. The major issue to be discussed will be these recently developed approximation techniques which are believed to give good alternatives, to say the least, to approximation methods like Pade or Hermite-Pade.

**Brief Biography of the Speaker:** N. A. BAYKARA was born in Istanbul,Turkey on 29th July 1948. He received a B.Sc. degree in Chemistry from Bosphorous University in 1972. He obtained his PhD from Salford University, Greater Manchester, Lancashire,U.K. in 1977 with a thesis entitled “Studies in Self Consistent Field Molecular Orbital Theory”, Between the years 1977–1981 and 1985–1990 he worked as a research scientist in the Applied Maths Department of The Scientific Research Council of Turkey. During the years 1981-1985 he did postdoctoral research in the Chemistry Department of Montreal University, Quebec, Canada. Since 1990 he is employed as a Staff member of Marmara University. He is now a Full Professor of Applied Mathematics mainly teaching Numerical Analysis courses and is involved in HDMR research and is a member of Group for Science and Methods of Computing in Informatics Institute of Istanbul Technical University. Other research interests of his for him are “Density Functional Theory” and “Fluctuationlessness Theorem and its Applications” which he is actually involved in. Most recent of his concerns is focused at efficient remainder calculations of Taylor expansion via Fluctuation–Free Integration, and Fluctuation–Free Expectation Value Dynamics.

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