Finite Differences, Finite Elements, Finite Volumes, Boundary Elements

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Preface

This year the 2nd WSEAS International Conference on FINITE DIFFERENCES, FINITE ELEMENTS, FINITE VOLUMES, BOUNDARY ELEMENTS (F-and-B '09) was held in Tbilisi, Georgia. The Conference remains faithful to its original idea of providing a platform to discuss iterative methods, nonlinear problems, multidimensional systems, Godunov finite volume discretizations, genetic algorithms etc. with participants from all over the world, both from academia and from industry.

Its 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 this conference are published in this Book that will be indexed by ISI. Please, check it: www.worldses.org/indexes as well as in the CD-ROM Proceedings. They will be also available in the E-Library of the WSEAS. The best papers will be also promoted in many Journals for further evaluation.

A Conference such as this 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

Table of Contents

Plenary Lecture 1

Numerical Simulations of Incompressible Flows Using the Finite-Element-Method

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Abstract: A numerical simulation of fluid flows is an essential part of flow investigations currently emerged in the wide range of technical applications. Various combinations of the mathetical approaches have been design, investigated and successfully applied in the computational codes in order to achieve the effectiveness and robustness of computational methods. For instance, powerful stabilization techniques based on the pressure-stabilized Petrov-Galerkin and streamline Petrov-Galerkin approaches are widely used in the finite-element codes in order to effectively suppress any numerical instabilities and oscillations that can appear during calculation processes. To solve the mathematical equation system of the incompressible fluid flow, for instance, a splitting scheme is commonly used that yields an implicit Poisson-type equation for the pressure and an explicit predictor-corrector step for the velocity calculation, respectively.

In the frame of this invited paper, a finite-element code partially based on the previous mentioned methods will be introduced. This code was successfully validated on several test cases including a transient channel flow or a flow driven by a rotating magnetic field in the laminar Stokes flow regime. The convergence study proved the second order accuracy in time and space. In the transient flow regime, this code was validated by means of the linear stability analysis carried out in the flow driven by the rotating and traveling magnetic fields. Results obtained were in good agreement to results observed experimentally as well as numerically. Numerical results of the magnetically induced flow were also compared with experiments and good agreement in the mean velocity field and turbulent properties was found.

The mathematical model was implemented on top of the multi-grid library that provides data structures and procedures for grid handling and adaptation. The parallelization is based on the grid partitioning where the grid generated by an external grid generator is decomposed into a specific number of partitions using the MeTiS package. This parallel implementation was tested on the simple flow problem and the excellence effectiveness of the parallelization process (depended on the local computational station) was demonstrated.

The computational finite-element-code have been used for numerical studies of the unsteady flows driven by a rotating and traveling magnetic fields in a axisymmetrical and non-axisymmetrical containers. By means of RMF flow studies in the cylindrical container, important roles of the Taylor-Gotler type vortices on the formation of mixing processes inside of the container was revealed and studied in detail. For result verifications, mean velocity profiles at different moderate Taylor numbers (proportional to Reynolds numbers) were confronted by experimental results and good agreement within a tolerance of 3 % was found even for energy spectra. In the flow study of the non-axisymetrical container, similar flow features were observed in axisymmetrical and non-axisymmetrical containers, however, we did also find differences e.g. in the velocity field distribution.

In last several months, the finite-element code was also significantly extended about new turbulent models based on a hybrid URANS/LES approach. This promising method provides nowadays the best approach to the turbulence modeling in numerical simulations. The preliminary simulations of unsteady turbulent flows past a cylinder calculated using the Detached Eddy Simulation approach were carried out and results obtained were in good agreement to experimental results.

Brief Biography of the Speaker: Assoc. Prof. Karel Frana Ph.D. is working at the Technical University of Liberec, Department of Power Engineering Equipment Czech Republic. He provides lectures for numerical methods in the Thermodynamics and Fluid Mechanics and he is supervisor of Ph.D. students at the same university. Simultaneously, he is active as a guest in several German research projects at the Technical University in Dresden in Germany.

In 1999, he received the Master Degree by the Technical University of Liberec, from 2001 to 2005; he worked as a research assistant at the Technical University in Dresden, Institute of Aerospace Engineering, Germany. In 2004, he received Ph.D. by Technical University of Liberec. Since 2005, he has been working at TU Liberec, at the Department of Power Engineering Equipment.

In 2006, he carried out several lectures at the Jiaotong University in China. In 2007 he visited as a guest the Technical University in Vienna, Austria and had several lectures connected to the topic of numerical methods in CFD. Meanwhile, he has been regularly a guest at the Technical University in Dresden in the frame of Collaborative research SFB 609.

Mr. Frana works in 2 domestic and 1 international (EU) projects. He is interested for numerical methods in the Fluid Mechanics and Thermodynamics, visualization techniques, Finite-Element Methods (FEM), parallelization and grid adaptations. He has developed a finite-element code that is used by Ph.D. students for numerical simulations of the incompressible turbulent flow.

In the last five years, he has 3 papers in cited journals e.g. Physics of Fluids, European Journal of Mechanics Fluids B, Journal of Visualization, more than 8 papers in the other journals e.g. Journal of Magnetohydrodynamics, Astronomical Notes etc., about 20 paper contributions on the international conferences.

He is a member of the editorial board of the Journal of Applied Science in Thermodynamics and Fluid Mechanics regularly published by the Technical University in Liberec Czech Republic.

Plenary Lecture 2

Meshfree-based Finite Volume Method

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Abstract: In this study, the Finite Volume Method (FVM) is implemented based on the meshfree interpolation together with the hybrid technique. By "hybrid" we mean that the stress field and the displacement field are interpolated independently. In this way, the process of differentiating shape functions, which is complicated and time-consuming, is not involved. The efficiency is accordingly enhanced significantly with high precision.

Plenary Lecture 3

Dual BEM since 1986

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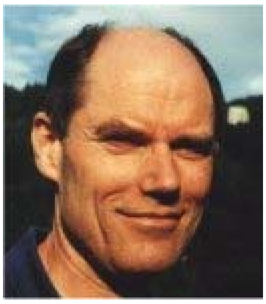
Abstract: In this talk, the development of dual BEM is reviewed since its appearance in 1986 by Hong and Chen. Roles of hypersigularity are also examined in the computational mechanics. A novel method using the SVD (singular value decomposition) for problems with degenerate boundaries was proposed without employing hypersingular formulation and subdomain approach in 2003. Some traps of BEM in engineering applications, degenerate scale, spurious eigenvalues and fictitious frequencies, are investigated. We provide a perspective on the nonuniqueness and its treatment, including degenerate boundary, degenerate scale, spurious eigensolution, fictitious frequency and corner problems as shown in Table 1, in the boundary integral formulation and boundary element method (BEM). All the nonuniqueness problems originate from the rank deficiency in the influence matrix. Both the Fredholm alternative theorem and SVD technique are employed to study the nonuniqueness problems. Based on the circulant properties and degenerate kernels as analytical tools for circular and annular cases, mathematical analysis can be done. Updating terms and updating documents of the SVD technique are utilized. The roles of right and left unitary vectors of SVD in BEM and their relations to true, spurious and fictitious modes are examined by using the Fredholm alternative theorem. Two methods, CHIEF and CHEEF techniques, for dealing with the nonuniqueness problems in BEM are proposed. Null-fields of nonuniqueness problems and the related works since 1984 are also addressed. Only key references of NTOU/MSV group are contained here.

Brief Biography of the Speaker: Jeng-Tzong Chen, born in 1962, received a BS degree in Civil Engineering, an M.S. in Applied Mechanics, and a Ph.D. in Civil Engineering, respectively, in 1984, 1986 and 1994, from National Taiwan University, Taipei, Taiwan, R.O.C. He had worked as a research assistant in the Structural Division of the Department of Rocket and Missile System, Chung Shan Institute of Science and Technology, from 1986 to 1990. In 1994, he was invited to be an Associate Professor in the Department of Harbor and River Engineering, National Taiwan Ocean University, Keelung, Taiwan, R.O.C. He was promoted to a full professor in 1998. Later in 2004, he was selected to be the Distinguished Professor. In 2007, he was selected as the Life-time Distinguished Professor. He is also the Professor of Department of Mechanical and Mechatronic Engineering of Taiwan Ocean University. His major interest is computational mechanics. He had derived the theory of dual integral equations for boundary value problems with degenerate boundary. Prof. Chen also developed four dual BEM programs for the BVPs of Laplace equation, Helmholtz equation, bi-Helmholtz and modified Helmhotlz equation and Navier equation. Recently, he also employed the null field integral equations to solve BVPs with circular boundaries including holes and inclusions. He wrote two books in Chinese on dual BEM and FEM using MSC/NASTRAN, respectively. He was ever invited to give plenaray and keynote lectures, e.g., twice in World Congress on Computational Mechanics (WCCM4 in Buenos Aries and WCCM5 in Vienna) and FEM/BEM 2003 in St. Petersburg, Russia. Also, he is the editor of Journal of the Chinese Institute of Civil and Hydraulic Engineering. He has been the Editor of Journal of Marine Science and Technology and the guest editor of J. Chinese Institute of Engineers. He won several times of Outstanding Research Awards from National Science Council, Taiwan. He also won the Wu, Ta-You Memorial Award in 2002. He is currently the member of editorial board of five international SCI journals. Until now, he has published more than 126 SCI papers on BEM and FEM in technical Journals. More than 615 papers are found to cite Chen’s work.. Boundary element method is one focus of Professor Chen's research interests. Others may be categorized into two areas. One is vibration and acoustics, and the other is computational mechanics.

Plenary Lecture 4

Finite Element Simulation of the Dynamics of Tethered Satellite Systems



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Abstract: Tethered satellite systems, that is two or more satellites in orbit, connected by thin cables up to a length of 100 km, have gained great importance over the past two decades and are now a well established new space technology with great application potential for future space missions ([1]). In the period of preparation of the two tether experiments during the Space Shuttle flights in 1992 and 1996 many practical and theoretical investigations have been carried out, best documented in [2], [3] and [4].
There exist numerous important practical applications, ranging from energy production, making use of the magnetic field of the Earth, to orbit raising or deorbiting of satellites just by cutting the tether. Some have been already tested in several flights in orbit around the Earth. These practical applications of tethered satellite systems follow from an important property of the system in orbit. If the system's mass center is moving on a circular orbit, the system possesses a local vertical configuration. For constant tether length and if the tether is not too long this vertical configuration is a stable relative equilibrium of the system. Of course, theoretically this requires a perfectly spherical Earth. Within technical accuracy this assumption can be considered to be fulfilled.
To start and to finish a mission, deployment and retrieval of a subsatellite from a mother spaceship moving on a circular orbit must be performed and is a delicate operation because both processes lead to unstable motions with respect to the stable radial relative equilibrium of such a system for constant tether length. Therefore simulation tools for the implementation of stabilizing control are needed. In the literature various different formulations of the equations of motion are given. In [1] they are derived from balance principles, whereas we also derive them from a variational principle, yielding them in weak form, which is especially well suited for the numerical discretisation by Finite Elements.
Basically, the equations of motion of a tethered satellite system are given by a set of coupled partial and ordinary differential equations, which due to large displacements from the local vertical are strongly non-linear and, especially important for the numerical integration, the equations have the mathematically unpleasant property to be stiff. Under a stiff system of differential equations one usually understands a system, the solution of which consists of a smooth slowly changing part and a transient part which is fast changing with large gradient. If the system is damped, this transient part approaches the smooth part very rapidly. Obviously, motions are present in such a system which are changing on different time scales. For the discretization by means of Finite Elements we introduce first, following [5] a moving, but non-rotating reference frame, which moves on a prescribed orbit in the neighborhood of the system. We only require that the moving reference frame stays close enough to the system to avoid numerical problems due to small changes of large quantities. Hence the problem is split into two parts, describing the so-called nearfield and farfield dynamics. Following [5] we perform, first, a discretization in time. This reverse order of discretisation compared with the traditional approach is motivated in [5] by the argument that proceeding this way one is able to avoid having the details of the spatial discretisation obscure the time integration of finite rotations which has to be performed for the motion of the endbodies. The discretisation in time results in a nonlinear functional that is solved by means of the Newton-Raphson-method by a sequence of linearized problems. To calculate a step in the Newton Raphson method we have to discretize all quantities which are still continuous in space. This discretization is performed by means of Finite Elements. The continuous tether is divided into a number of elements and the displacement inside an element is interpolated by ansatz-functions. Inserting cubic ansatz-functions and calculating the projections we finally obtain a system of linearized equations. The structure of the matrix of the linear system is of the form of an arrow matrix, where the arrow shape is a consequence of the changing mass composition of the system due to deployment or retrieval. For constant tether length the arrow shape disappears and the matrix has block diagonal form. In this paper we want to discuss a selected number of interesting problems which arise in the treatment of such systems. We start with modelling. Then we focus on some problems related to the variational formulation of the equations of motion. Special attention is devoted to the numerical solution procedure by Finite Elements. We compare the usually used displacement coordinates with an alternative set of variables called

Minakov's variables introduced in [1] which turn out to be superior for the effective numerical integration of the mathematically stiff system of partial and ordinary differential equations if the tether is physically very stiff.
Finally we shortly consider a string moving with geostationary angular velocity in its radial relative equilibrium configuration around the Earth, reaching from the surface of the Earth far beyond the geostationary height ([6]). If properly done it could be used as track for an Earth to space elevator. Besides the question of feasibility from a technological point of view, which is answered positive by Carbon nanotubes also the question concerning the stability is relevant.

Brief Biography of the Speaker: Date and place of birth: 1943, Villach, Austria; June 1966 Dipl.Ing. Mechanical Engineering at TU-Vienna; 1970 Dr.techn. (PhD) at TU-Vienna; 1970–1979 Assistant professor at TU-Vienna; since 1979 Full Professor for Mechanics at TU Vienna; 1985–1987 Dean of the Faculty of Mechanical Engineering. 1990 Honorary Doctorate (Dr.h.c.) of the Technical University of Budapest; 2000 Schrodinger prize awarded by the Austrian Academy of Sciences; 2002 Elected as Member of the Austrian Academy of Sciences
Member in Advisory Board of 5 International Scientific Journals, 200 research papers including review articles and book chapters, 7 books (editor), 2 books (author).

Plenary Lecture 5

Criteria of Strategic Behaviour and Optimum Trajectories for the Problem of Sequential Decision

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Abstract: The results of this paper are obtained starting from the formulation, in a generalized form, of a sequential decisional problem, related to which we suggest the solving of the following issues:
1. the determination of the optimum criteria for certain strategic behavior types of decision makers;
2. the specification of the conditions for which this criteria are equivalent;
3. the determination of certain important properties for the optimum trajectories;
4. establishing the conditions for which a decision maker can get and maintain an advantageous situation.
The strategic behavior of decision makers is analyzed considering the two existing possibilities: cautious strategic behavior and hazardous strategic behavior. In the case of decision makers having hazardous strategic behavior, there are analyzed all the optimum criteria which are already known with a specific view on certain relatively new and less studied criteria such as maximum probability criterion and different variants of entropic criteria.
In the case of cautious strategic behavior, the paper focuses on the maximum stability principle (with all variants of equilibrium solutions, maxmin solutions, minmax solutions) and the equalization principle (a relatively new and less studied criterion). The paper also analyses different qualitative situations which can appear while carrying out the decisional process: non-cooperative situations, partial cooperative situations and total cooperative situations. In the cases of partial cooperative and total cooperative situations, a new coalition criterion in the cooperative games theory is brought forward, namely the coalition in the sense of maximum probability. Within the cooperative game theory, there are two basic issues: the way coalitions are formed and the way payoffs are distributed to players. This new form of coalition allows the utility transfer and it is more general than the criterion based upon the concepts of characteristic function and imputation. Moreover, this form of coalition admits the determination of an optimal distribution of payoffs by solving an optimal problem which has an entropic efficiency criterion.
The theoretical results obtained are used in order to solve some major technical-economical problems: the analysis of systems' reliability, the analysis of the stability of mining works, the determination of some forecasting indicators, problems of ruination and financial arbitrage etc.

Brief Biography of the Speaker: Ilie Mitran graduated from the University of Timisoara in 1975, receiving the 5 years Diploma in Mathematics, specialization Operations Research. Five years later (1980) he has graduated from the Economic Studies Academy, receiving the 5 years Diploma in Economics, specialization in Cybernetics and Economic Planning. He joined in 1980 the University of Petrosani, Romania. In 1988, he received the Ph.D. in Mathematics, based upon the doctoral thesis "Mathematical Contributions regarding Cybernetic Modeling of the Decisional Process". The extended version of the doctoral thesis was published in France with the title "Co–operative and Partial Co–operative Decisional Models", AMSE Publishing House, 1990. In 1998, he received the second Ph. D. in Engineering with the doctoral thesis "Contributions regarding the Systems Renewal Modeling". In 1992 he became Associated Professor of Applied Mathematics. He is a member of American Mathematical Society (AMS - SUA), Association for the Advancement of Modeling and Simulation Techniques in Enterprises (AMSE - France), Society for Industrial and Applied Mathematics (SIAM - SUA), Mathematical Association of America (MAA - SUA). He is also a member of the International Advisory Board for The Academic Periodical Publication of the Faculty of Economics at the University of Miskolc. His general research interests are: Applied Mathematics, Decision Modeling, Econometrics, Operations Research.
He published 9 books, more than 80 paper in various scientific journals and international conference proceedings.
He served as the Dean of Faculty of Science, between 2000-2008. Nowadays, he serves as the Vice – Rector of the University of Petrosani.

Authors Index