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Recent Advances in Finite Differences - Finite Elements - Finite Volumes - Boundary Elements

Proceedings of the 3rd WSEAS International Conference on Finite Differences - Finite Elements - Finite Volumes - Boundary Elements (F-and-B '10)

Universitatea Politehnica, Bucharest, Romania, April 20-22, 2010

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Preface

This year the 3rd WSEAS International Conference on FINITE DIFFERENCES - FINITE ELEMENTS - FINITE VOLUMES - BOUNDARY ELEMENTS (F-and-B '10) was held at Universitatea Politehnica, Bucharest, Romania, April 20-22, 2010. The conference remains faithful to its original idea of providing a platform to discuss finite differences, finite elements, finite volumes, boundary elements, applications in, fluid mechanics, composite materials, thermodynamics, statistical physics, heat and mass transfer, electromagnetics, acoustics, wave propagation and scattering,, quantum mechanics, solid state physics and material science, elasticity theory and structural engineering, damage mechanics and fracture, environmental engineering (pollution), earth sciences, geology, geoengineering, mathematical biology, oceanology 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

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Plenary Lecture 1

Advanced Algorithms for Numerical Simulation of Coupled Engineering Problems

Associate Professor Ion Carstea
University Of Craiova. ROMANIA
E-mail: ion_crst@yahoo.com

Abstract: In our lecture we intend to review the state-of-the-art of advanced iterative algorithms for solving large sparse systems such as arising in coupled engineering problems. The solution of practical problems of mathematical physics ultimately relies on solving a system of non-linear partial derivative equations and this is only achieved by iterative numerical methods using parallel computers. Iterative solution methods proceed by adding successive corrections to some arbitrary initial approximation, but unfortunately these methods are very sensitive to specific features of the system to be solved. A procedure call preconditioning is possible but is not always used.
Any electromagnetic device is the house of two or more physical fields that interact by a number of parameters as the material properties, the field sources etc. In other words we have not separate problems for engineers from different science branches although for economic reasons in terms of computer resources, each physical field is considered as though it was separate field and generates a problem which is solved independently. The subsystems and numerical solutions are finally coupled together in such way that interactions are satisfied with an “acceptable” degree of accuracy. This is a simplified natural approach for the analysis of large or complex structures but the accuracy of the analysis is not good. Naturally the systems interact in any time moment so that an independent analysis can not be considered.
In our lecture a special attention is for the domain decomposition method in the context of the finite element method. Domain decomposition is an efficient method for large distributed-parameter systems. This is an iterative method at the level of the subdomains. The technique of dividing a large physical system into a system of components is very old but is used extensively nowadays. The motivation of this approach is that we have an increased computing power with advanced computer architectures so that it is an antisocial fact to ignore this real computing power for complex systems.
We limit our presentation to a large class of systems defined by elliptic-parabolic mathematical models that represents the basis of the electromagnetic-thermal problems. The numerical models are obtained by the finite differences and finite element methods. The motivation is simple: for parabolic problems we use an explicit scheme for temporal discretization, and for elliptic problem we use the finite element method. As target example we use an electromagnetic-thermal coupled problem from electrical engineering. In the algorithmic skeletons for this class of problems we are guided by the implementation of the algorithms on the parallel computers with emphasis on parallel computers (MIMD architectures).

Brief Biography of the Speaker:
Ion Carstea is a Lecturer at the Computer Engineering and Communications Department, Faculty of Automatics, Computers and Electronics, University of Craiova, Romania. He has a BSc and MSc in Automatics from the University of Craiova, Romania. He has a Ph.D. in Automatics from the University of Ploiesti, Romania. Also, he has a BSc and MSc in Mathematics from the Natural Sciences Faculty, University of Craiova, Romania.
He is an active reviewer of WSEAS activities and is an author of tens of papers included in volumes of the WSEAS conferences. He attended as plenary lecturer (7) and chair (7) of WSEAS conferences in Arcachon (France), Venice (Italy), and Bucharest (Romania).
Ion Carstea was director of the research projects supported by international grants at University of Houston (USA)- 6 months (Fulbright Fellowship), at the University of Coimbra, Portugal – 9 months (NATO grant), at the Polytechnics of Milano, Italy- 4 months (a CNR-NATO grant). In 2004 he was member in a research team at the Mathematics Department, University of Trento, Italy, for 2 months.
Ion Carstea has published 11 books in the area of programming languages, advanced computers and CAD of the electromagnetic devices. He is the author of more than 150 papers in revues, scientific journals and international conference proceedings. He is a reviewer for several WSEAS International Conferences and was a member in many international scientific committees. He was included in editorial board of 5 volumes of the WSEAS Proceedings edited in 2007-2008, and is one of the authors of WSEAS book “The finite element method”. His research interests include parallel algorithms for numerical simulation of the distributed-parameter systems of elliptic and parabolic types, development of software products for coupled and inverse problems in engineering, CAD of the electromagnetic device based on the finite element method, and domain decomposition method for engineering applications.

Plenary Lecture 2

Experimental Research Aimed at Promoting Railway Vehicle Prototypes to Railroad Travel

Professor Ion Copaci
Engineering Faculty
"Aurel Vlaicu" University
No. 77 Revolutiei Bld., Arad
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Abstract: The conception, execution, promoting to the railway and use of a railway vehicle follow a complex process that submits to rigorous rules and concepts of applied mechanics. Consequently, a well determined scientific course is generally established, attached to a series of imperiously necessary practical norms:
1. Establishing a set of technical norms that comprise the technical characteristics together with the resulting economic and environmental impact.
2. A theoretical study on the constructive and technical solutions adopted and the finalization of the functional technical characteristics for the execution of the vehicle.
3. The actual design phase, preceded by a series of studies that aim at establishing solutions that will be included in the design of the prototype expecting validation by experimental research.
4. The experimental research that follows a program comprising the response of the vehicle in use, in regards to bearing structures' resistance, travel safety and travel dynamics.
5. Modification of the design and implicitly of the prototype as a consequence of the findings from the research and trial program and restarting the experimental research process up to finalization. Completing the vehicle implies fulfilling all the requirements established initially.
The experimental research program implies a series of experimental studies which are centered on three important aspects:
1. Experimental studies on the resistance of bearing structures of railway vehicles in static and dynamic regimes, to the shock strains due to collision and the random strains that appear during travel on the railroad.
2. Studies regarding travel safety.
3. Studies on travel dynamics.
Finally, the railway vehicle must respond positively to the total of tests that it is subjected to, thus offering the guarantee of a favourable behavior during use.

Brief Biography of the Speaker:
Ion Copaci graduated from the "Traian Vuia" Polytechnic Institute in Timisoara, Romania, Faculty of Mechanics. He received his Ph.D. in the field of Mechanical Engineering with the thesis „Contributions on the Behaviour of the Bearing Structures of Railway Cars During the Longitudinal Shock Caused by Collision", presented at the "Politehnica" University Timisoara, Faculty of Mechanics, Department of Rolling Stock.
Technical Experience: research in the area of vibrations and shocks on railway vehicles (rolling quality, repeated shock), bearing structure resistance (lifetime, fatigue), elastic elements that equip the suspension or shock insulators of railway vehicles, torsional rigidity and travel safety, quantitative determinations (MATHAR) of the internal stresses on the bearing structures of bogies and Francis turbine rotors. Contributions and experimental research for the promotion on the railway of over 150 freight and passenger railway car prototypes, in almost 30 countries on 5 continents, as a result of over 30 years of research.
Nowadays he is a Professor at the Faculty of Engineering of "Aurel Vlaicu" University, Arad, Romania.
Field of specialization: Railway Transport Vehicles, with disciplines taught: "Dynamics of Railway Vehicles" and "Experimental Research on Railway Vehicles".
He has published over 120 research papers, 7 books and 4 inventor's licences.
He is a member of 6 societies and professional associations and he is a member of the Ukrainian Academy of Science.

Plenary Lecture 3

Accurate Element Method Methodology for Finding and Controlling the Quasi-Analytic Solutions of First-Order Partial Differential Equations with Variable Coefficients

Professor Maty Blumenfeld
Politehnica University Bucharest, ROMANIA

Abstract: A first order Partial Differential Equation (PDE) with variable coefficients has to be integrated on a domain D, divided in rectangular sub-domains (elements). The four sides of the element – having the dimensions B(base) ? H(height) – will be referred as South, West, North and East edges, respectively. A known initial condition is considered on the South Edge and a boundary condition on the West Edge. Integrated symbolically the PDE leads to an integral equation. The Accurate Element Method (AEM) performs the integration replacing the unknown solution by a Concordant Function (CF), which is a complete two variables polynomial of high degree. The number of terms of a complete G degree CF is given by NT=(G+1) (G+2)/2. For instance a five degree CF includes 21 terms. In order to obtain RIGOROUSLY 21 equations AEM uses three sources:

1. The integral equation (1 equation)
2. The initial and boundary conditions (11 equations)
3. The PDE itself and its derivatives applied in the nodes of the element (9 equations). Because the North-East node – referred as Target Node – is included in these equations, the AEM is an implicit method, unconditionally stable and allowing the use of elements with large dimensions that can be considered as improper by other methods.

The standard strategy for the numerical integration of PDEs is usually based on two considerations: "the shape of the element has to be close to a square" and b. "the precision improves when the number of elements increases". The AEM that obtains for each element a quasi-analytic solution represented by the CF, introduces a fundamentally different strategy that can be summarized as "best shape-controlled accuracy":

A. Best shape. Many examples solved by using CFs have shown that only in some particular cases the element has to be square. The AEM introduces a more strong analysis from which it results that the shape of the element has to be adapted to the particular case of the PDE to be integrated. This analysis is based on the facility offered by the quasi-analytic solution, which can be replaced in the PDE leading to residual functions evaluated as root mean square values on the North and East sides of the element. Based on the ratio of these residuals one can establish the best shape of the element for each particular. The correctness of this evaluation can be linked to the characteristic curves of the PDE. For instance, for the particular case of a PDE with variable coefficients the standard strategy based on square elements lead – when the number of elements were increased – to erratic results, while the AEM strategy based on rectangular elements having the ratio H/B=7 lead to strictly convergent results.

B. Accuracy check. The AEM can closely check the accuracy of the Target Value in two ways: based on the root mean square values of the residual functions and by successively computing the Target Value with two or many Concordant Functions. For a particular example for which the root mean square value was RMS ?10-11 it resulted:

Five degree CF with 21 terms: Target value = 5.453688724546589
Seven degree CF with 36 terms: Target value = 5.453688723145416
The two values coincide with 9 digits, so that one can consider 5.45368872 as reliable.

Brief Biography of the Speaker:

1. Born: 15 august 1928
2. Education: Engineer, Politehnica, Bucharest, 1947-1952
3. Ph.D., 1964:"The three unknowns method applied to the mechanic systems". Further studies of the method developed also by other authors. The method has been presented in different books and is used for the "Strength of materials" lectures.
4. Activities:

a. Professor since 1970 at the "Strength on Materials" department
- Strength of materials
- Finite Element Method (Has introduced for the first time in Politechnica University Bucharest the FEM course non-officially in 1980 and officially in 1990)

b. Guidance for many Ph.D. works (Strength of materials, theory of elasticity and plasticity)
c. President (1990-1995) of SIAC (Society for the computer aided engineering). Honorary President since 1995.
d. Scientific counselor INAS (Institute for the System Analysis) – Craiova (Romania)
e. More than 100 research and experimental works for industry and research institute.