Finite Volume Methods With Local Refinement For Convection

This book constitutes the thoroughly refereed post-conference proceedings of the Second International Conference on High Performance Computing and Applications, HPCA 2009, held in Shangahi, China, in August 2009. The 71 revised papers presented together with 10 invited presentations were carefully selected from 324 submissions. The papers cover topics such as numerical algorithms and solutions; high performance and grid computing; novel approaches to high performance computing; massive data storage and processsing; and hardware acceleration.

This volume gathers contributions from participants of the Introductory School and the IHP thematic quarter on Numerical Methods for PDE, held in 2016 in Cargese (Corsica) and Paris, providing an opportunity to disseminate the latest results and envisage fresh challenges in traditional and new application fields. Numerical analysis applied to the approximate solution of PDEs is a key discipline in applied mathematics, and over the last few years, several new paradigms have appeared, leading to entire new families of discretization methods and solution algorithms. This book is intended for researchers in the field.

We hope that among these chapters you will find a topic which will raise your interest and engage you to further investigate a problem and build on the presented work. This book could serve either as a textbook or as a practical guide. It includes a wide variety of concepts in FVM, result of the efforts of scientists from all over the world. However, just to help you, all book chapters are systemized in three general groups: New techniques and algorithms in FVM; Solution of particular problems through FVM and Application of FVM in medicine and engineering. This book is for everyone who wants to grow, to improve and to investigate.

This book solves the open problems in fluid flow modeling through the fractured vuggy carbonate reservoirs. Fractured vuggy carbonate reservoirs usually have complex pore structures, which contain not only matrix and fractures but also the vugs and cavities. Since the vugs and cavities are irregular in shape and vary in diameter from millimeters to meters, modeling fluid flow through fractured vuggy porous media is still a challenge. The existing modeling theory and methods are not suitable for such reservoir. It starts from the concept of discrete fracture and fracture-vug networks model, and then develops the corresponding mathematical models and numerical methods, including discrete fracture model, discrete fracture-vug model, hybrid model and multiscale models. Based on these discrete porous media models, some equivalent medium models and methods are also discussed. All the modeling and methods shared in this book offer the key recent solutions into this area.

Basic and Fundamental Issues

Finite Volume Method

A Study of Well-balanced Finite Volume Methods and Refinement Indicators for the Shallow Water Equations

Spectral Methods for Incompressible Viscous Flow

Finite Volume Methods for Hyperbolic Problems

An Advanced Introduction with OpenFOAM® and Matlab

This book contains proceedings from the Seventh International Conference on Domain Decomposition Methods, held at Pennsylvania State University in October 1993. The term ``domain decomposition'' has for nearly a decade been associated with the partly iterative, partly direct algorithms explored in the proceedings of this conference. Noteworthy trends in the current volume include progress in dealing with so-called ``bad parameters'' in elliptic partial differential equation problems, as well as developments in partial differential equations outside of the elliptically-dominated framework. Also described here are convergence and complexity results for novel discretizations, which bring with them new challenges in the derivation of appropriate operators for coarsened spaces. Implementations and architectural considerations are discussed, as well as partitioning tools and environments. In addition, the book describes a wide array of applications, from semiconductor device simulation to structural mechanics to aerodynamics. Presenting many of the latest results in the field, this book offers readers an up-to-date guide to the many facets of the theory and practice of domain decomposition.

Scientific Computing & Applications

The simulation of compressible fluid flows describing engineering applications using finite difference or finite volume methods is complicated by both the difficulty in representing complex geometries using rectangular grids and by the memory size and speed of modern supercomputers. The composite overlapping grid approach can be used to represent complicated geometries using a set of logically rectangular grids, thus allowing the use of finite difference or finite volume methods to approximate the partial differential equations. This approach can also be used to accomplish local mesh refinement for the purpose of resolving locally detailed behavior in the flow fields. This paper discusses the composite overlapping grid method, in particular presenting the modifications necessary to the standard finite volume approach in order to use these grids. Computed examples from compressible hypersonic flow are present as well. 15 refs., 4 figs.

This book provides an elementary yet comprehensive introduction to the numerical solution of partial differential equations (PDEs). Used to model important phenomena, such as the heating of apartments and the behavior of electromagnetic waves, these equations have applications in engineering and the life sciences, and most can only be solved approximately using computers.? Numerical Analysis of Partial Differential Equations Using Maple and MATLAB provides detailed descriptions of the four major classes of discretization methods for PDEs (finite difference method, finite volume method, spectral method, and finite element method) and runnable MATLAB? code for each of the discretization methods and exercises. It also gives self-contained convergence proofs for each method using the tools and techniques required for the general convergence analysis but adapted to the simplest setting to keep the presentation clear and complete. This book is intended for advanced undergraduate and early graduate students in numerical analysis and scientific computing and researchers in related fields. It is appropriate for a course on numerical methods for partial differential equations.

Computational Fluid Dynamics for Incompressible Flows

Computational Mechanics
Numerical Analysis of Partial Differential Equations Using Maple and MATLAB
Algebraic Multiscale Finite-volume Methods for Reservoir Simulation
The Hybrid High-Order Method for Polytopal Meshes
Computational Fluid Dynamics for Engineers

The book aims to provide a comprehensive understanding of the most recent developments in finite volume methods. Its focus is on the development and analysis of these methods for the two- and three-dimensional Navier-Stokes equations, supported by extensive numerical results. It covers the most used lower-order finite element pairs, with well-posedness and optimal analysis for these finite volume methods. The authors have attempted to make this book self-contained by offering complete proofs and theoretical results. While most of the material presented has been taught by the authors in a number of institutions over the past several years, they also include several updated theoretical results for the finite volume methods for the incompressible Navier-Stokes equations. This book is primarily developed to address research needs for students and academic and industrial researchers. It is particularly valuable as a research reference in the fields of engineering, mathematics, physics, and computer sciences. .

This first volume of the proceedings of the 8th conference on "Finite Volumes for Complex Applications" (Lille, June 2017) covers various topics including convergence and stability analysis, as well as investigations of these methods from the point of view of compatibility with physical principles. It collects together the focused invited papers comparing advanced numerical methods for Stokes and Navier–Stokes equations on a benchmark, as well as reviewed contributions from internationally leading researchers in the field of analysis of finite volume and related methods, offering a comprehensive overview of the state of the art in the field. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation, and recent decades have brought significant advances in the theoretical understanding of the method. Many finite volume methods preserve further qualitative or asy mptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability. Due to these properties, finite volume methods belong to the wider class of compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete level. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. The book is a valuable resource for researchers, PhD and master's level students in numerical analysis, scientific computing and related fields such as partial differential equations, as well as engineers working in numerical modeling and simulations.

The second edition of this book is a self-contained introduction to computational fluid dynamics (CFD). It covers the fundamentals of the subject and is ideal as a text or a comprehensive reference to CFD theory and practice. New approach takes readers seamlessly from first principles to more advanced and applied topics. Presents the essential components of a simulation system at a level suitable for those coming into contact with CFD for the first time, and is ideal for those who need a comprehensive refresher on the fundamentals of CFD. Enhanced pedagogy features chapter objectives, hands-on practice examples and end of chapter exercises. Extended coverage of finite difference, finite volume and finite element methods. New chapters include an introduction to grid properties and the use of grids in practice. Includes material on 2-D inviscid, potential and Euler flows, 2-D viscous flows and Navier-Stokes flows to enable the reader to develop basic CFD simulations. Includes best practice guidelines for applying existing commercial or shareware CFD tools.

This volume is intended to mark the 75th birthday of A R Mitchell, of the University of Dundee. It consists of a collection of articles written by numerical analysts having links with Ron Mitchell, as colleagues, collaborators, former students, or as visitors to Dundee. Ron Mitchell is known for his books and articles contributing to the numerical analysis of partial differential equations; he has also made major contributions to the development of numerical analysis in the UK and abroad, and his many human qualitites are such that he is held in high regard and looked on with great affection by the numerical analysis community. The list of contributors is evidence of the esteem in which he is held, and of the way in which his influence has spread through his former students and fellow workers. In addition to contributions relevant to his own specialist subjects, there are also papers on a wide range of subjects in numerical analysis.

Fractured Vuggy Carbonate Reservoir Simulation

Numerical Methods for Partial Differential Equations

Finite Volumes for Complex Applications IX - Methods, Theoretical Aspects, Examples

Computing the Distribution

Finite Volume Methods for the Incompressible Navier-Stokes Equations

Scientific Computing and Applications

Solving economic models with heterogenous agents requires computing aggregate dynamics consistent with individual behaviors. This paper introduces the ?nite volume method from the mathe-matics literature to en the set of numerical methods available to compute dynamics in continuous time. Finite volume discretization methods allow theoretically consistent dimensional and local adaptivity that guarantee the mass conservati and positivity of the distribution function of the discretized system. This paper shows examples of 1) the Ornstein-Uhlenbeck process 2) the Aiyagari-Bewley-Huggett (wealth+income heterogeneity) model and 3) the li (wealth+income+age heterogeneity) model. The numerical exercises show that for the current dimensionality of the problems in economics, the ?nite volume method (with or without adaptivity) outperforms pre-existin methods. This paper further provides a companion open-source implementation of the ?nite volume method at github.com/sehyoun/adaptive_finite_volume to reduce the testing time of the ?nite volume method.

Finite Volume Methods for Hyperbolic ProblemsCambridge University Press

This book is the second volume of proceedings of the 8th conference on "Finite Volumes for Complex Applications" (Lille, June 2017). It includes reviewed contributions reporting successful applications in the fields of fluid dynamics, computational geosciences, structural analysis, nuclear physics, semiconductor theory and other topics. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation, and recent decades have brought significant advances in the theoretical understanding of the method. Many finite volume methods preserve further qualitative or asymptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability. Due to these properties, finite volume methods belong to the w class of compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete l evel. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. The book is useful for researchers, PhD and master's level students in numerical analysis, scientific computing and related fields such as partial differential equations, as well as for engineers working in numerical modeling and simulations.

The GAMM Committee for "Efficient Numerical Methods for Partial Differential Equations" organizes workshops on subjects concerning the algorithmical treat ment of partial differential equations. The topics are discretization methods like the finite element and finite volume method for various types of applications in structural and fluid mechanics. Particular attention is devoted to advanced solu tion techniques. th The series o such workshops was continued in 1993, January 22-24, with the 9 Kiel-Seminar on the special topic "Adaptive Methods Algorithms, Theory and Applications" at the Christian-Albrechts-University of Kiel. The seminar w attended by 76 scientists from 7 countries and 23 lectures were given. The list of topics contained general lectures on adaptivity, special discretization schemes, error estimators, space-time adaptivity, adaptive solvers grid me thods, wavelets, and parallelization. Special thanks are due to Michael Heisig, who carefully compiled the contribu tions to this volume. November 1993 Wolfgang Hackbusch Gabriel Wittum v Contents Page A AUGE, G. LUBE, D. WEISS: Galerkin/Least-Squares-FEM and Ani- tropic Mesh Refinement. 1 P. BASTIAN, G. WmUM : Adaptive Multigrid Methods: The UG Concept. 17 R. BEINERT, D. KRONER: Finite Volume Methods with Local Mesh Alignment in 2-D. 38 T. BONK: A New Algorithm for Multi-Dimensional Adaptive Nume- cal Quadrature. 54 F.A. BORNEMANN: Adaptive Solution of One-Dimensional Scalar Conservation Laws with Convex Flux. 69 J. CANU, H. RITZDORF : Adaptive, Block-Structured Multigrid on Local Memory Machines. 84 S. DAHLKE, A. KUNaTH: Biorthogonal Wavelets and Multigrid. 99 B. ERDMANN, R.H.W. HOPPE, R.

Finite Difference and Finite Volume Methods

From Analysis to Algorithms

Numerical Analysis

Finite Volume Methods with Local Refinement for Convection-diffusion Problems

Adaptive Finite Volume Methods for Economic Models with Heterogeneous Agents

Finite Volumes for Complex Applications VIII - Methods and Theoretical Aspects

This book, first published in 2002, contains an introduction to hyperbolic partial differential equations and a powerful class of numerical methods for approximating their solution, including both linear problems and nonlinear conservation laws. These equations describe a wide range of wave propagation and transport phenomena arising in nearly every scientific and engineering discipline. Several applications are described in a self-contained manner, along with much of the mathematical theory of hyperbolic problems. High-resolution versions of Godunov's method are developed, in which Riemann problems are solved to determine the local wave structure and limiters are then applied to eliminate numerical oscillations. These methods were originally designed to capture shock waves accurately, but are also useful tools for studying linear wave-propagation problems, particularly in heterogenous material. The methods studied are implemented in the CLAWPACK software package and source code for all the examples presented can be found on the web, along with animations of many of the simulations. This provides an excellent learning environment for understanding wave propagation phenomena and finite volume methods.

Numerical Methods for Partial Differential Equations: Finite Difference and Finite Volume Methods focuses on two popular deterministic methods for solving partial differential equations (PDEs), namely finite difference and finite volume methods. The solution of PDEs can be very challenging, depending on the type of equation, the number of independent variables, the boundary, and initial conditions, and other factors. These two methods have been traditionally used to solve problems involving fluid flow. For practical reasons, the finite element method, used more often for solving problems in solid mechanics, and covered extensively in various other texts, has been excluded. The book is intended for beginning graduate students and early career professionals, although advanced undergraduate students may find it equally useful. The material is meant to serve as a prerequisite for students who might go on to take additional courses in computational mechanics, computational fluid dynamics, or computational electromagnetics. The notations, language, and technical jargon used in the book can be easily understood by scientists and engineers who may not have had graduate-level applied mathematics or computer science courses. Presents one of the few available resources that comprehensively describes and demonstrates the finite volume method for unstructured mesh used frequently by practicing code developers in industry Includes step-by-step algorithms and code snippets in each chapter that enables the reader to make the transition from equations on the page to working codes Includes 51 worked out examples that comprehensively demonstrate important mathematical steps, algorithms, and coding practices required to numerically solve PDEs, as well as how to interpret the results from both physical and mathematic perspectives

This well-written book explains the theory of spectral methods and their application to the computation of viscous incompressible fluid flow, in clear and elementary terms. With many examples throughout, the work will be useful to those teaching at the graduate level, as well as to researchers working in the area.

Publisher Description

Proceedings of the Ninth GAMM-Seminar Kiel, January 22–24, 1993

A.R. Mitchell 75th Birthday Volume

Numerical Techniques for Global Atmospheric Models

Proceedings of the 2007 International Symposium on Computational Mechanics in Beijing
Solving Hyperbolic Equations with Finite Volume Methods
Handbook of Numerical Methods for Hyperbolic Problems

This is the most authoritative and accessible single-volume reference book on applied mathematics. Featuring numerous entries by leading experts and organized thematically, it introduces readers to applied mathematics and its uses; explains key concepts; describes important equations, laws, and functions; looks at exciting areas of research; covers modeling and simulation; explores areas of application; and more. Modeled on the popular Princeton Companion to Mathematics, this volume is an indispensable resource for undergraduate and graduate students, researchers, and practitioners in other disciplines seeking a user-friendly reference book on applied mathematics. Features nearly 200 entries organized thematically and written by an international team of distinguished contributors Presents the major ideas and branches of applied mathematics in a clear and accessible way Explains important mathematical concepts, methods, equations, and applications Introduces the language of applied mathematics and the goals of applied mathematical research Gives a wide range of examples of mathematical modeling Covers continuum mechanics, dynamical systems, numerical analysis, discrete and combinatorial mathematics, mathematical physics, and much more Explores the connections between applied mathematics and other disciplines Includes suggestions for further reading, cross-references, and a comprehensive index

This textbook introduces several major numerical methods for solving various partial differential equations (PDEs) in science and engineering, including elliptic, parabolic, and hyperbolic equations. It covers traditional techniques that include the classic finite difference method and the finite element method as well as state-of-the-art numerical methods, such as the high-order compact difference method and the radial basis function meshless method. Helps Students Better Understand Numerical Methods through Use of MATLAB® The authors uniquely emphasize both theoretical numerical analysis and practical implementation of the algorithms in MATLAB, making the book useful for students in computational science and engineering. They provide students with simple, clear implementations instead of sophisticated usages of MATLAB functions. All the Material Needed for a Numerical Analysis Course Based on the authors’ own courses, the text only requires some knowledge of computer programming, advanced calculus, and difference equations. It includes practical examples, exercises, references, and problems, along with a solutions manual for qualifying instructors. Students can download MATLAB code from www.crcpress.com, enabling them to easily modify or improve the codes to solve their own problems.

This thesis studies solutions to the shallow water equations analytically and numerically. The study is separated into three parts. The first part is about well-balanced finite volume methods to solve steady and unsteady state problems. A method is said to be well-balanced if it preserves an unperturbed steady state at the discrete level. We implement hydrostatic reconstructions for the well-balanced methods with respect to the steady state of a lake at rest. Four combinations of quantity reconstructions are tested. Our results indicate an appropriate combination of quantity reconstructions for dealing with steady and unsteady state problems. The second part presents some new analytical solutions to debris avalanche problems and reviews the implicit Carrier-Greenspan periodic solution for flows on a sloping beach. The analytical solutions to debris avalanche problems are derived using characteristics and a variable transformation technique. The analytical solutions are used as benchmarks to test the performance of numerical solutions. For the Carrier-Greenspan periodic solution, we show that the linear approximation of the Carrier-Greenspan periodic solution may result in large errors in some cases. If an explicit approximation of the Carrier-Greenspan periodic solution is needed, higher order approximations should be considered. We propose second order approximations of the Carrier-Greenspan periodic solution and present a way to get higher order approximations. The third part discusses refinement indicators used in adaptive finite volume methods to detect smooth and nonsmooth regions. In the adaptive finite volume methods, smooth regions are coarsened to reduce the computational costs and nonsmooth regions are refined to get more accurate solutions. We consider the numerical entropy production and weak local residuals as refinement indicators. Regarding the numerical entropy production, our work is the first to implement the numerical entropy production as a refinement indicator into adaptive finite volume methods used to solve the shallow water equations. Regarding weak local residuals, we propose formulations to compute weak local residuals on nonuniform meshes. Our numerical experiments show that both the numerical entropy production and weak local residuals are successful as refinement indicators.

The proceedings of the 9th conference on "Finite Volumes for Complex Applications" (Bergen, June 2020) are structured in two volumes. The first volume collects the focused invited papers, as well as the reviewed contributions from internationally leading researchers in the field of analysis of finite volume and related methods. Topics covered include convergence and stability analysis, as well as investigations of these methods from the point of view of compatibility with physical principles. Altogether, a rather comprehensive overview is given on the state of the art in the field. The properties of the methods considered in the conference give them distinguished advantages for a number of applications. These include fluid dynamics, magnetohydrodynamics, structural analysis, nuclear physics, semiconductor theory, carbon capture utilization and storage, geothermal energy and further topics. The second volume covers reviewed contributions reporting successful applications of finite volume and related methods in these fields. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation. Many finite volume methods preserve further qualitative or asymptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability, making the finite volume methods compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete level. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. The book is a valuable resource for researchers, PhD and master’s level students in numerical analysis, scientific computing and related fields such as partial differential equations, as well as engineers working in numerical modeling and simulations.

A Local Lagrangian Finite Volume Method for the Numerical Solution of Conservation Laws
Numerical Treatment of Partial Differential Equations
State of the Art Techniques
Princeton Companion to Applied Mathematics
A Finite Volume Method for Solving the Navier-Stokes Equations on Composite Overlapping Grids
Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics

The present book – through the topics and the problems approach – aims at filling a gap, a real need in our literature concerning CFD (Computational Fluid Dynamics). Our presentation results from a large documentation and focuses on reviewing the present day most important numerical and computational methods in CFD. Many theoreticians and experts in the field have expressed their - terest in and need for such an enterprise. This was the motivation for carrying out our study and writing this book. It contains an important systematic collection of numerical working instruments in Fluid Dyn- ics. Our current approach to CFD started ten years ago when the Univ- sity of Paris XI suggested a collaboration in the field of spectral methods for fluid dynamics. Soon after – preeminently studying the numerical approaches to Navier–Stokes nonlinearities – we completed a number of research projects which we presented at the most important inter- tional conferences in the field, to gratifying appreciation. An important qualitative step in our work was provided by the dev- opment of a computational basis and by access to a number of expert softwares. This fact allowed us to generate effective working programs for most of the problems and examples presented in the book, an - pect which was not taken into account in most similar studies that have already appeared all over the world.

This monograph provides an introduction to the design and analysis of Hybrid High-Order methods for diffusive problems, along with a panel of applications to advanced models in computational mechanics. Hybrid High-Order methods are new-generation numerical methods for partial differential equations with features that set them apart from traditional ones. These include: the support of polytopal meshes, including non-star-shaped elements and hanging nodes; the possibility of having arbitrary approximation orders in any space dimension; an enhanced compliance with the physics; and a reduced computational cost thanks to compact stencil and static condensation. The first part of the monograph lays the foundations of the method, considering linear scalar second-order models, including scalar diffusion – possibly heterogeneous and anisotropic – and diffusion-advection-reaction. The second part addresses applications to more complex models from the engineering sciences: non-linear Leray-Lions problems, elasticity, and incompressible fluid flows. This book is primarily intended for graduate students and researchers in applied mathematics and numerical analysis, who will find here valuable analysis tools of general scope.

The first volume of the proceedings of the 7th conference on "Finite Volumes for Complex Applications" (Berlin, June 2014) covers topics that include convergence and stability analysis, as well as investigations of these methods from the point of view of compatibility with physical principles. It collects together the focused invited papers, as well as the reviewed contributions from internationally leading researchers in the field of analysis of finite volume and related methods. Altogether, a rather comprehensive overview is given of the state of the art in the field. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation. Recent decades have brought significant success in the theoretical understanding of the method. Many finite volume methods preserve further qualitative or asymptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability. Due to these properties, finite volume methods belong to the wider class of compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete level. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. Researchers, PhD and masters level students in numerical analysis, scientific computing and related fields such as partial differential equations will find this volume useful, as will engineers working in numerical modeling and simulations.

Computational Mechanics is the proceedings of the International Symposium on Computational Mechanics, ISCM 2007. This conference is the first of a series created by a group of prominent scholars from the Mainland of China, Hong Kong, Taiwan, and overseas Chinese, who are very active in the field. The book includes 22 full papers of plenary and semi-plenary lectures and approximately 150 one-page summaries.

Domain Decomposition Methods in Scientific and Engineering Computing

Numerical Methods for Conservation Laws

Handbook of Numerical Analysis

The Finite Volume Method in Computational Fluid Dynamics

Adaptive Methods — Algorithms, Theory and Applications

Finite Volumes for Complex Applications VIII - Hyperbolic, Elliptic and Parabolic Problems

This book surveys recent developments in numerical techniques for global atmospheric models. It is based upon a collection of lectures prepared by leading experts in the field. The chapters reveal the multitude of steps that determine the global atmospheric model design. They encompass the choice of the equation set, computational grids on the sphere, horizontal and vertical discretizations, time integration methods, filtering and diffusion mechanisms, conservation properties, tracer transport, and considerations for designing models for massively parallel computers. A reader interested in applied numerical methods but also the many facets of atmospheric modeling should find this book of particular relevance.

This textbook explores both the theoretical foundation of the Finite Volume Method (FVM) and its applications in Computational Fluid Dynamics (CFD). Readers will discover a thorough explanation of the FVM numerics and algorithms used for the simulation of incompressible and compressible fluid flows, along with a detailed examination of the components needed for the development of a collocated unstructured pressure-based CFD solver. Two particular CFD codes are explored. The first is uFVM, a three-dimensional unstructured pressure-based finite volume academic CFD code, implemented within Matlab. The second is OpenFOAM®, an open source framework used in the development of a range of CFD programs for the simulation of industrial scale flow problems. With over 220 figures, numerous examples and more than one hundred exercise on FVM numerics, programming, and applications, this textbook is suitable for use in an introductory course on the FVM, in an advanced course on numerics, and as a reference for CFD programmers and researchers.

This book deals with discretization techniques for partial differential equations of elliptic, parabolic and hyperbolic type. It provides an introduction to the main principles of discretization and gives a presentation of the ideas and analysis of advanced numerical methods in the area. The book is mainly dedicated to finite element methods, but it also discusses difference methods and finite volume techniques. Coverage offers analytical tools, properties of discretization techniques and hints to algorithmic aspects. It also guides readers to current developments in research.

Computational fluid dynamics, CFD, has become an indispensable tool for many engineers. This book gives an introduction to CFD simulations of turbulence, mixing, reaction, combustion and multiphase flows. The emphasis on understanding the physics of these flows helps the engineer to select appropriate models to obtain reliable simulations. Besides presenting the equations involved, the basics and limitations of the models are explained and discussed. The book combined with tutorials, project and power-point lecture notes (all available for download) forms a complete course. The reader is given hands-on experience of drawing, meshing and simulation. The tutorials cover flow and reactions inside a porous catalyst, combustion in turbulent non-premixed flow, and multiphase simulation of evaporation spray respectively. The project deals with design of an industrial-scale selective catalytic reduction process and allows the reader to explore various design improvements and apply best practice guidelines in the CFD simulations.

High Performance Computing and Applications

Finite Volumes for Complex Applications VII-Methods and Theoretical Aspects

Proceedings of the Seventh International Conference on Domain Decomposition, October 27-30, 1993, the Pennsylvania State University

An Introduction to Computational Fluid Dynamics The Finite Volume Method, 2/e

Powerful Means of Engineering Design

Computational Partial Differential Equations Using MATLAB

Handbook of Numerical Methods for Hyperbolic Problems explores the changes that have taken place in the past few decades regarding literature in the design, analysis and application of various numerical algorithms for solving hyperbolic equations. This volume provides concise summaries from experts in different types of algorithms, so that readers can find a variety of algorithms under different situations and readily understand their relative advantages and limitations. Provides detailed, cutting-edge background explanations of existing algorithms and their analysis Ideal for readers working on the theoretical aspects of algorithm development and its numerical analysis Presents a method of different algorithms for specific applications and the relative advantages and limitations of different algorithms for engineers or readers involved in applications Written by leading subject experts in each field who provide breadth and depth of content coverage

Finite volume methods are used in numerous applications and by a broad multidisciplinary scientific community. The book communicates this important tool to students, researchers in training and academics involved in the training of students in different science and technology fields. The selection of content is based on the author's experience giving PhD and master courses in different universities. In the book the introduction of new concepts and numerical methods go together with simple exercises, examples and applications that contribute to reinforce them. In addition, some of them involve the execution of MATLAB codes. The author promotes an understanding of common terminology with a balance between mathematical rigor and physical intuition that characterizes the origin of the methods. This book aims to be a first contact with finite volume methods. Once readers have studied it, they will be able to follow more specific bibliographical references and use commercial programs or open source software within the framework of Computational Fluid Dynamics (CFD).

Conservation laws are the mathematical expression of the principles of conservation and provide effective and accurate predictive models of our physical world. Although intense research activity during the last decades has led to substantial advances in the development of powerful computational methods for conservation laws, their solution remains a challenge and many questions are left open; thus it is an active and fruitful area of research. Numerical Methods for Conservation Laws: From Analysis to Algorithms: offers the first comprehensive introduction to modern computational methods and their analysis for hyperbolic conservation laws, building on intense research activities for more than four decades of development; discusses classic results on monotone and finite difference/finite volume schemes, but emphasizes the successful development of high-order accurate methods for hyperbolic conservation laws; addresses modern concepts of TVD and entropy stability, strongly stable Runge-Kutta schemes, and limiter-based methods before discussing essentially nonoscillatory schemes, discontinuous Galerkin methods, and spectral methods; explores algorithmic aspects of these methods, emphasizing one- and two-dimensional problems and the development and analysis of an extensive range of methods; includes MATLAB software with which all main methods and computational results in the book can be reproduced; and demonstrates the performance of many methods on a set of benchmark problems to allow direct comparisons. Code and other supplemental material are available online at www.siam.org/books/cs18.

This textbook covers fundamental and advanced concepts of computational fluid dynamics, a powerful and essential tool for fluid flow analysis. It discusses various governing equations used in the field, their derivations, and the physical and mathematical significance of partial differential equations and the boundary conditions. It covers fundamental concepts of finite difference and finite volume methods for diffusion, convection-diffusion problems both for cartesian and non-orthogonal grids. The solution of algebraic equations arising due to finite difference and finite volume discretization are highlighted using direct and iterative methods. Pedagogical features including solved problems and unsolved exercises are interspersed throughout the text for better understanding. The textbook is primarily written for senior undergraduate and graduate students in the field of mechanical engineering and aerospace engineering, for a course on computational fluid dynamics and heat transfer. The textbook will be accompanied by teaching resources including a solution manual for the instructors. Written clearly and with sufficient foundational background to strengthen fundamental knowledge of the topic. Offers a detailed discussion of both finite difference and finite volume methods. Discusses various higher-order bounded convective schemes, TVD discretisation schemes based on the flux limiter essential for a general purpose CFD computation. Discusses algorithms connected with pressure-linked equations for incompressible flow. Covers turbulence modelling like k-ε, k-ω, SST k-ω, Reynolds Stress Transport models. A separate chapter on best practice guidelines is included to help CFD practitioners.

FVCA 9, Bergen, Norway, June 2020
Second International Conference, HPCA 2009, Shanghai, China, August 10-12, 2009, Revised Selected Papers

FVCA 8, Lille, France, June 2017
Basics of Fluid Mechanics and Introduction to Computational Fluid Dynamics
Design, Analysis, and Applications

One of the major challenges in reservoir simulation is posed by the existence of multiple scales in reservoirs and the resulting high resolution geophysical models. It is usually too expensive to compute directly on the finest geo-cellular scale. On the other hand, the accuracy of simulating subsurface flow relies strongly on the detailed geophysical properties of natural heterogeneous formations. Multiscale methods have been shown to be very promising to bridge the gap between the geological and flow-simulation scales. However, there are a few limitations in existing multiscale methods, e.g., the extension to physical mechanisms (such as compressibility, gravity and capillary pressure), and difficulties for cases with channelized permeability or high anisotropy. Moreover, the multiscale method has been applied only to the flow problem for efficient solutions of the pressure and velocity fields, while the transport problem is solved on the fine scale. In this work, we develop an algebraic multiscale framework for coupled flow and transport problems in heterogeneous porous media. An operator-based multiscale method (OBMM) is proposed to solve general multiphase flow problems. The key ingredients of the method are two algebraic multiscale operators, prolongation and restriction, with which the multiscale solution can be constructed algebraically. It is straightforward to extend OBMM to general flow problems that involve more physical mechanisms, such as compressibility, gravity and capillary pressure. The efficiency and accuracy of OBMM are demonstrated by a wide range of problems. An adaptive multiscale formulation for the saturation equations is developed within the algebraic multiscale framework, which is the first multiscale treatment of transport problems. Our multiscale formulation employs a conservative restriction operator and three adaptive prolongation operators. For the time interval of interest, the physical domain is divided into three distinct regions according to the coarse-scale saturation solution. Then, different prolongation operators are defined and used adaptively in different regions to construct the fine-scale saturation field. The multiscale computations of coupled flow and transport further improve the computational efficiency over the original multiscale finite-volume method, which is already significantly more efficient than fine-scale methods. An efficient two-stage algebraic multiscale (TAMS) method is also developed, which overcomes the limitations of the multiscale finite-volume method for channelized permeability fields and highly anisotropic problems. The TAMS method consists of two stages, one global and one local. In the global stage, a multiscale solution is obtained purely algebraically from the fine-scale matrix. The prolongation operator is obtained algebraically using the wirebasket ordered reduced system of the original fine-scale coefficient matrix. In the second stage, a local solution is constructed from a simple block preconditioner, such as Block ILU(0) (BILU), or an Additive Schwarz (AS) method. The TAMS method is purely algebraic and only needs the fine-scale coefficient matrix and the wirebasket ordering information of the multiscale grid. Thus, the TAMS method can be applied as a preconditioner for solving the large-scale linear systems associated with the flow problem. The TAMS method converges rapidly even for problems with channelized permeability fields and high anisotropy ratios. TAMS also preserve the favorable property of local mass conservation of the multiscale finite-volume method. Therefore, the TAMS method can be applied as either an efficient linear solver or a fast approximation approach with very good accuracy.
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