The Finite Volume Method In Computational Fluid Dynamics An Advanced Introduction With Openfoami 1 2 And Matlab Fluid Mechanics And Its Applications

The principles and practice of finite volume method are highlighted in this book. In this book, readers will find a subject which will increase their interest and involve them to further explore a challenge and work further on the presented solutions. This book can serve the purposes of both; a textbook and a practical guide. It presents a vast variety of ideas in FVM which is a result of the efforts of scientists from across the world. The major topics covered in this book are novel techniques and algorithms in FVM, solution of particular problems through FVM and application of FVM in medicine and engineering. This book is for anyone who wants to grow, improve and explore.

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 wider 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 book covers intimately all the topics necessary for the development of a robust magnetohydrodynamic (MHD) code within the framework of the cell-centered finite volume method (FVM) and its applications in space weather study. First, it presents a brief review of existing MHD models in studying solar corona and the heliosphere. Then it introduces the cell-centered FVM in three-dimensional computational domain. Finally, the book presents some applications of FVM to the MHD codes on spherical coordinates in various research fields of space weather, focusing on the development of the 3D Solar-InterPlanetary space-time Conservation Element and Solution Element (SIP-CESE) MHD model and its applications to space weather studies in various aspects. The book is written for senior undergraduates, graduate students, lecturers, engineers and researchers in solar-terrestrial physics, space weather theory, modeling, and prediction, computational fluid dynamics, and MHD simulations. It helps readers to fully understand and implement a robust and versatile MHD code based on the cell-centered FVM.

An Advanced Introduction with OpenFOAM® and Matlab

Application of Finite Volume Method in Fluid Dynamics and Inverse Design Based Optimization

The Finite Volume Method in Computational Rheology

Powerful Means of Engineering Design

Introductory Finite Volume Methods for PDEs

Application of Control Volume Based Finite Element Method (CVFEM) for Nanofluid Flow and Heat Transfer discusses this powerful numerical method that uses the advantages of both finite volume and finite element methods for the simulation of multi-physics problems in complex geometries, along with its applications in heat transfer and nanofluid flow. The book applies these methods to solve various applications of nanofluid in heat transfer enhancement. Topics covered include magnetohydrodynamic flow, electrohydrodynamic flow and heat transfer, melting heat transfer, and nanofluid flow in porous media, all of which are demonstrated with case studies. This is an important research reference that will help readers understand the principles and applications of this novel method for the analysis of nanofluid behavior in a range of external forces. Explains governing equations for nanofluid as working fluid Includes several CVFEM codes for use in nanofluid flow analysis Shows how external forces such as electric fields and magnetic field effects nanofluid flow

Publisher Description

The schemes are analyzed regarding their nonlinear stability Recently developed entropy schemes are presented A formalism is introduced for source terms

Theory, Analysis, and Numerics

Fabrication, Implementation, and Applications

Microfluidics and Nanofluidics Handbook

and Well-Balanced Schemes for Sources

Examples and Their Comparisons

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 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.

Matthäus Jäger examines the simulation of liquid-gas flow in fuel tank systems and its application to sloshing problems. The author focuses at first on the physical model and the assumptions necessary to derive the respective partial differential equations. The second step involves the cell-centered finite volume method and its application to fluid dynamic problems with free surfaces using a volume of fluid approach. Finally, the application of the method for different use cases is presented followed by an introduction to the methodology for the interpretation of the results achieved.

Magnetohydrodynamic Modeling of the Solar Corona and Heliosphere

Solving Hyperbolic Equations with Finite Volume Methods

Finite Volume Methods for Deterministic and Stochastic PDEs

The Finite Volume Method for the Richards Equation

Finite Volumes for Complex Applications VII-Methods and Theoretical Aspects

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.

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.

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.

High Resolution Finite Volume Methods on Arbitrary Grids Via Wave Propagation

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

FVCA 8, Lille, France, June 2017

Principles and Practice of Finite Volume Method

Application of Control Volume Based Finite Element Method (CVFEM) for Nanofluid Flow and Heat Transfer

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.

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.

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).

Numerical Methods for Partial Differential Equations

A finite volume method for computation of fluid flow in complex geometries

An Introduction to Computational Fluid Dynamics

The Finite Volume Method

Finite Volume Methods for Hyperbolic Problems

Elementary descriptions of finite element and finite difference methods are given while the finite volume method is briefly overviewed. Examples illustrating finite element and finite difference methods are worked out. Finally, comparisons of these methods between themselves and with some examples from literature are given. (AN)

This comprehensive handbook presents fundamental aspects, fabrication techniques, introductory materials on microbiology and chemistry, measurement techniques, and applications of microfluidics and nanofluidics. The second volume focuses on topics related to experimental and numerical methods. It also covers fabrication and applications in a variety of areas, from aerospace to biological systems. Reflecting the inherent nature of microfluidics and nanofluidics, the book includes as much interdisciplinary knowledge as possible. It provides the fundamental science background for newcomers and advanced techniques and concepts for experienced researchers and professionals.

The Finite Volume Method in Computational Rheology.

Handbook of Numerical Analysis

Computation of Flows by the Finite Volume Method as Applied to Unstructured Meshes

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

A Finite Volume Method for Solving the Navier-Stokes Equations on Composite Overlapping Grids

The Finite Volume Method in Computational Fluid Dynamics

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.

The Finite Volume Method in Computational Fluid DynamicsAn Advanced Introduction with OpenFOAM ® and MatlabSpringer

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. .

Fuel Tank Sloshing Simulation Using the Finite Volume Method

Coupling of the Finite Volume Method and the Boundary Element Method

Nonlinear Stability of Finite Volume Methods for Hyperbolic Conservation Laws

Aspects of the Finite Volume Method for Compressible Flows

Finite Difference and Finite Volume Methods

In previous work by the author, a generalization of Godunov's method for systems of conservation laws has been developed and analyzed that can be applied with arbitrary time steps on arbitrary grids in one space dimension. Stability for arbitrary time steps is achieved by allowing waves to propagate through more than one mesh cell in a time step. In this paper the method is extended to second order accuracy and to a finite volume method in two space dimensions. This latter method is based on solving one dimensional normal and tangential Riemann problems at cell interfaces and again propagating waves through one or more mesh cells. By avoiding the usual time step restriction of explicit method, it is possible to use reasonable time steps on irregular grids where the minimum cell area is much smaller than the average cell. Boundary conditions for the Euler equations are discussed and special attention is given to the case of a Cartesian grid cut by an irregular boundary. In this case small grid cells arise only near the boundary, and it is desirable to use a time step appropriate for the regular interior cells. Numerical results in two dimensions show that this can be achieved. (RH).

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.

This comprehensive text presents the fundamentals of Computer Fluid Dynamics simply and clearly.

A Finite Volume Method for the Steady Two-dimensional Transonic Flow Based on Euler Equations

Finite Volume Method

Finite Element, Finite Difference, and Finite Volume Methods

Finite Volume Methods for the Incompressible Navier-Stokes Equations

Finite Volumes for Complex Applications VIII - Methods and Theoretical Aspects