

Meshfree Methods Moving Beyond The Finite Element Method Second Edition

The First International Conference on Computational Methods (ICCM04), organized by the department of Mechanical Engineering, National University of Singapore, was held in Singapore, December 15-17, 2004, with great success. This conference proceedings contains some 290 papers from more than 30 countries/regions. The papers cover a broad range of topics such as meshfree particle methods, Generalized FE and Extended FE methods, inverse analysis and optimization methods. Computational methods for geomechanics, machine learning, vibration, shock, impact, health monitoring, material modeling, fracture and damage mechanics, multi-physics and multi-scales simulation, sports and environments are also included. All the papers are pre-reviewed before they are accepted for publication in this proceedings. The proceedings will provide an informative, timely and invaluable resource for engineers and scientists working in the important areas of computational methods.

This is the 20th Volume in the series Memorial Tributes compiled by the National Academy of Engineering as a personal remembrance of the lives and outstanding achievements of its members and foreign associates. These volumes are intended to stand as an enduring record of the many contributions of engineers and engineering to the benefit of humankind. In most cases, the authors of the tributes are contemporaries or colleagues who had personal knowledge of the interests and the engineering accomplishments of the deceased. Through its members and foreign associates, the Academy carries out the responsibilities for which it was established in 1964. Under the charter of the National Academy of Sciences, the National Academy of Engineering was formed as a parallel organization of outstanding engineers. Members are elected on the basis of significant contributions to engineering theory and practice and to the literature of engineering or on the basis of demonstrated unusual accomplishments in the pioneering of new and developing fields of technology. The National Academies share a responsibility to advise the federal government on matters of science and technology. The expertise and credibility that the National Academy of Engineering brings to that task stem directly from the abilities, interests, and achievements of our members and foreign associates, our colleagues and friends, whose special gifts we remember in this book.

As we attempt to solve engineering problems of ever increasing complexity, so must we develop and learn new methods for doing so. The Finite Difference Method used for centuries eventually gave way to Finite Element Methods (FEM), which better met the demands for flexibility, effectiveness, and accuracy in problems involving complex geometry. Now, Meshfree Particle Methods is a comprehensive and systematic exposition of particle methods, meshfree Galerkin and partition of unity methods, molecular dynamics methods, and multiscale methods. Most theories, computational formulations, and simulation results presented are recent developments in meshfree methods. They were either just published recently or even have not been published yet, many of them resulting from the authors' own research. The presentation of the technical content is heuristic and explanatory with a balance between mathematical rigor and engineering practice. It can be used as a graduate textbook or a comprehensive source for researchers, providing the state of the art on Meshfree Particle Methods.

Error Estimates for Advanced Galerkin Methods

Meshfree Particle Methods

Proceedings of ICCES 2020. Volume 2

Meshfree Methods for Partial Differential Equations III

Computational Biomechanics

Moving Beyond the Finite Element Method, Second Edition

This volume introduces the basic mathematical tools behind conformal mapping, describes advances in technique, and illustrates a broad range of applications. 1991 edition. Includes 247 figures and 38 tables.

Meshfree Methods Moving Beyond the Finite Element Method, Second Edition CRC Press

Understand How to Use and Develop Meshfree Techniques An Update of a Groundbreaking Work Reflecting the significant advances made in the field since the publication of its predecessor, Meshfree Methods: Moving Beyond the Finite Element Method, Second Edition systematically covers the most widely used meshfree methods. With 70% new material, this edition addresses important new developments, especially on essential theoretical issues. New to the Second Edition Much more details on fundamental concepts and important theories for numerical methods Discussions on special properties of meshfree methods, including stability, convergence, accuracy, efficiency, and bound property More detailed discussion on error estimation and adaptive analysis using meshfree methods Developments on combined meshfree/finite element method (FEM) models Comparison studies using meshfree and FEM Drawing on the author's own research, this book provides a single-source guide to meshfree techniques and theories that can effectively handle a variety of complex engineering problems. It analyzes how the methods work, explains how to use and develop the methods, and explores the problems associated with meshfree methods. To access MFree2D (copyright, G. R. Liu), which accompanies MESHFREE METHODS: MOVING BEYOND THE FINITE ELEMENT METHOD, Second Edition (978-1-4200-8209-8) by Dr. G. R. Liu, please go to the website: www.ase.uc.edu/~liugr An access code is needed to use program – to receive it please email Dr. Liu directly at: liugr@ucmail.uc.edu Dr. Liu will reply to you directly with the code, and you can then proceed to use the software.

This is the first-ever book on smoothed particle hydrodynamics (SPH) and its variations, covering the theoretical background, numerical techniques, code implementation issues, and many novel and interesting applications. It contains many appealing and practical examples, including free surface flows, high explosive detonation and explosion, underwater explosion and water mitigation of explosive shocks, high velocity impact and penetration, and multiple scale simulations coupled with the molecular dynamics method. An SPH source code is provided and coupling of SPH and molecular dynamics is discussed for multiscale simulation, making this a friendly book for readers and SPH users.

Moving Particle Semi-implicit Method

The Meshless Local Petrov-Galerkin (MLPG) Method

A Meshfree Particle Method for Fluid Dynamics

Computational and Experimental Simulations in Engineering

Computational Methods for Fracture

Smoothed Finite Element Methods

Extended Finite Element and Meshfree Methods provides an overview of, and investigates, recent developments in extended finite elements with a focus on applications to material failure in statics and dynamics. This class of methods is ideally suited for applications, such as crack propagation, two-phase flow, fluid-structure-interaction, optimization and inverse analysis because they do not require any remeshing. These methods include the original extended finite element method, smoothed extended finite element method (XFEM), phantom node method, extended meshfree methods, numerical manifold method and extended isogeometric analysis. This book also addresses their implementation and provides small MATLAB codes on each sub-topic. Also discussed are the challenges and efficient algorithms for tracking the crack path which plays an important role for complex engineering applications. Explains all the important theory behind XFEM and meshfree methods Provides advice on how to implement XFEM for a range of practical purposes, along with helpful MATLAB codes Draws on the latest research to explore new topics, such as the applications of XFEM to shell formulations, and extended meshfree and extended isogeometric methods Introduces alternative modeling methods to help readers decide what is most appropriate for their work

This book gathers the latest advances, innovations, and applications in the field of computational engineering, as presented by leading international researchers and engineers at the 26th International Conference on Computational & Experimental Engineering and Sciences (ICCES), held in Phuket, Thailand on January 6-10, 2021. ICCES covers all aspects of applied sciences and engineering: theoretical, analytical, computational, and experimental studies and solutions of problems in the physical, chemical, biological, mechanical, electrical, and mathematical sciences. As such, the book discusses highly diverse topics, including composites; bioengineering & biomechanics; geotechnical engineering; offshore & arctic engineering; multi-scale & multi-physics fluid engineering; structural integrity & longevity; materials design & simulation; and computer modeling methods in engineering. The contributions, which were selected by means of a rigorous international peer-review process, highlight numerous exciting ideas that will spur novel research directions and foster multidisciplinary collaborations.

Generating a quality finite element mesh is difficult and often very time-consuming. Mesh-free methods operations can also be complicated and quite costly in terms of computational effort and resources. Developed by the authors and their colleagues, the smoothed finite element method (S-FEM) only requires a triangular/tetrahedral mesh to achieve more accurate results, a generally higher convergence rate in energy without increasing computational cost, and easier auto-meshing of the problem domain. Drawing on the authors' extensive research results, Smoothed Finite Element Methods presents the theoretical framework and development of various S-FEM models. After introducing background material, basic equations, and an abstracted version of the FEM, the book discusses the overall modeling procedure, fundamental theories, error assessment matters, and necessary building blocks to construct useful S-FEM models. It then focuses on several specific S-FEM models, including cell-based (CS-FEM), node-based (NS-FEM), edge-based (ES-FEM), face-based (FS-FEM), and a combination of FEM and NS-FEM (\square FEM). These models are then applied to a wide range of physical problems in solid mechanics, fracture mechanics, viscoelastoplasticity, plates, piezoelectric structures, heat transfer, and structural acoustics. Requiring no previous knowledge of FEM, this book shows how computational methods and numerical techniques like the S-FEM help in the design and analysis of advanced engineering systems in rapid and cost-effective ways since the modeling and simulation can be performed automatically in a virtual environment without physically building the system. Readers can easily apply the methods presented in the text to their own engineering problems for reliable and certified solutions. The finite difference method (FDM) has been used to solve differential equation systems for centuries. The FDM works well for problems of simple geometry and was widely used before the invention of the much more efficient, robust finite element method (FEM). FEM is now widely used in handling problems with complex geometry. Currently, we are using and developing even more powerful numerical techniques aiming to obtain more accurate approximate solutions in a more convenient manner for even more complex systems. The meshfree or meshless method is one such phenomenal development in the past decade, and is the subject of this book. There are many MFree methods proposed so far for different applications. Currently, three monographs on MFree methods have been published. Mesh Free Methods, Moving Beyond the Finite Element Method by GR Liu (2002) provides a systematic discussion on basic theories, fundamentals for MFree methods, especially on MFree weak-form methods. It provides a comprehensive record of well-known MFree methods and the wide coverage of applications of MFree methods to problems of solids mechanics (solids, beams, plates, shells, etc.) as well as fluid mechanics. The Meshless Local Petrov-Galerkin (MLPG) Method by Atluri and Shen (2002) provides detailed discussions of the meshfree local Petrov-Galerkin (MLPG) method and its variations. Formulations and applications of MLPG are well addressed in their book.

Proceedings of the 1st Asian Workshop on Meshfree Methods, Singapore, 16-18 December, 2002

Computational Partial Differential Equations Using MATLAB®

for Fracture Analysis of Structures

The Finite Element Method

An Introduction to Meshfree Methods and Their Programming

Meshfree approximation methods are a relatively new area of research, and there are only a few books covering it at present. Whereas other works focus almost entirely on theoretical aspects or applications in the engineering field, this book provides the salient theoretical results needed for a basic understanding of meshfree approximation methods. The emphasis here is on a hands-on approach that includes MATLAB routines for all basic operations. Meshfree approximation methods, such as radial basis function and moving least squares method, are discussed from a scattered data approximation and partial differential equations point of view. A good balance is supplied between the necessary theory and implementation in terms of many MATLAB programs, with examples and applications to illustrate key points. Used as class notes for graduate courses at Northwestern University, Illinois Institute of Technology, and Vanderbilt University, this book will appeal to both mathematics and engineering graduate students.

Written for practicing engineers and students alike, this book emphasizes the role of finite element modeling and simulation in the engineering design process. It provides the necessary theories and techniques of the FEM in a concise and easy-to-understand format and applies the techniques to civil, mechanical, and aerospace problems. Updated throughout for current developments in FEM and FEM software, the book also includes case studies, diagrams, illustrations, and tables to help demonstrate the material. Plentiful diagrams, illustrations and tables demonstrate the material Covers modeling techniques that predict how components will operate and tolerate loads, stresses and strains in reality Full set of PowerPoint presentation slides that illustrate and support the book, available on a companion website

Covering a range of fundamental topics essential to modern forensic investigation, the fourth edition of the landmark text Forensic Science: An Introduction to Scientific and Investigative Techniques presents contributions from experts in the field who discuss case studies from their own personal files. This edition has been thoroughly updated to r

The numerical treatment of partial differential equations with particle methods and meshfree discretization techniques is a active research field both in the mathematics and engineering community. This volume of LNCSE is a collection of the proceedings papers of the Fourth International Workshop on Meshfree Methods held in September 2007 in Bonn.

An Introduction to Scientific and Investigative Techniques, Fourth Edition

Meshfree Methods

Particle Methods for Multi-Scale and Multi-Physics

Meshless Methods in Solid Mechanics

Smoothed Particle Hydrodynamics

Mesh Free Methods

ECM2 is a completely updated and expanded Second Edition of the well-established Encyclopedia of Computational Mechanics. The project has once again been prepared under the guidance of three of the world's foremost experts in the field: Erwin Stein, Professor Emeritus, Stein Institut für Baumechanik und Numerische Mechanik, Leibniz Universität, Hannover, Germany René de Borst, Centenary Professor of Civil Engineering, University of Sheffield, UK Thomas J. R. Hughes, Peter O'Donnell Jr. Chair in Computational and Applied Mathematics and Professor of Aerospace Engineering and Engineering Mechanics, University of Texas at Austin, TX USA Though following the same structure as the first edition, ECM2 has been expanded from three to six volumes with the subjects "Fundamentals" in Volumes 1 & 2, "Solids and Structures" in Volumes 3 & 4, and "Fluids" in Volumes 5 & 6. It is published both in print and on line. Volumes 1 & 2, Fundamentals, contain contributions related to mathematics, mechanics, and computer science, and are structured as discretization methods, treating approximations with finite differences, discrete variational forms, boundary integral equations and further problem-oriented techniques, and the generation and visualization of geometry; meshes and results; various direct and iterative solvers; and time-dependent problems. Volumes 3 & 4, Solids and Structures, are organized into five different parts, namely, structural behavior; constitutive theories and their implementation; materials and processing; interaction problems; and identification, stochastics, and optimization. Volumes 5 & 6, Fluids, builds on the fundamentals described in Volumes 1 & 2. The chapters in Volumes 5 & 6 fall within four main groupings. The first grouping includes chapters describing additional basic methodologies used in computational fluid dynamics. The second comprises chapters on various aspects of incompressible viscous flows. The third part focuses on compressible fluid dynamics. The fourth pertains to problems involving moving domains and free surfaces, and application areas. With contributions from more than 50 leading experts drawn from around the globe, this is an essential and comprehensive reference for any university engineering department or corporation, containing must-have, up-to-date content of huge value to researchers, students and practitioners alike.

This book presents the complete formulation of a new advanced discretization meshless technique: the Natural Neighbour Radial Point Interpolation Method (NNRPIM). In addition, two of the most popular meshless methods, the EFGM and the RPIM, are fully presented. Being a truly meshless method, the major advantages of the NNRPIM over the FEM and other meshless methods, are the remeshing flexibility and the higher accuracy of the obtained variable field. Using the natural neighbour concept, the NNRPIM permits to determine organically the influence-domain, resembling the cellulae natural behaviour. This innovation permits the analysis of convex boundaries and extremely irregular meshes, which is an advantage in the biomechanical analysis, with no extra computational effort associated. This volume shows how to extend the NNRPIM to the bone tissue remodelling analysis, expecting to contribute with new numerical tools and strategies in order to permit a more efficient numerical biomechanical analysis.

Meshfree methods for the solution of partial differential equations gained much attention in recent years, not only in the engineering but also in the mathematics community. One of the reasons for this development is the fact that meshfree discretizations and particle models are often better suited to cope with geometric changes of the domain of interest, e.g. free surfaces and large deformations, than classical discretization techniques such as finite differences, finite elements or finite volumes. Another obvious advantage of meshfree discretizations is their independence of a mesh so that the costs of mesh generation are eliminated. Also, the treatment of time-dependent PDEs from a Lagrangian point of view and the coupling of particle models and continuous models gained enormous interest in recent years from a theoretical as well as from a practical point of view. This volume consists of articles which address the different meshfree methods (SPH, PUM, GFEM, EFGM, RKPM etc.) and their application in applied mathematics, physics and engineering.

This book is a collection of the papers from the proceedings of the 1st Asian Workshop on Meshfree Methods held in conjunction with the 2nd International Conference on Structural Stability & Dynamics (ICSSD02) on 16-18 December 2002 in Singapore. It contains 36 articles covering most of the topics in the rapidly developing areas of meshfree methods and extended finite element methods (X-FEM). These topics include domain discretization, boundary discretization, combined domain/boundary discretization, meshfree particle methods, collocation methods, X-FEM, etc. Papers on issues related to implementation and coding of meshfree methods are also presented. The areas of applications of meshfree methods include solving general partial differential equations, the mechanics of solids and structures, smart material/structures, soil-structures, fracture mechanics, fluid dynamics, impact, penetration, micro-fluidics, etc. In addition, techniques for field variable interpolation, such as the moving least squares (MLS) approximation, the point interpolation method (PIM), and radial PIM are reported. Contents: Meshfree Formulations Meshfree Methods for Smart Materials/Structures Meshfree Methods for Fracture Analysis Meshfree Methods for Membranes, Plates & Shells Meshfree Methods for Soil Meshfree Methods for CFD Boundary Meshfree Methods Coding, Error Estimation, Parallelisation Meshfree Particle Methods X-FEM Readership: Graduate and undergraduate students, researchers, academics, lecturers and engineers in civil engineering, engineering mechanics and mechanical engineering. Keywords: Meshfree Method; Meshless Method; SPH; X-FEM; Computational Mechanics; Computational Science; Fluid Dynamics; Modified Variational Principle; Smart Materials Extended Finite Element and Meshfree Methods

Memorial Tributes

Forensic Science

Computational Methods

Progress on Meshless Methods

Methods and Applications

Multi-scale and multi-physics modeling is useful and important for all areas in engineering and sciences. Particle Methods for Multi-Scale and Multi-Physics systematically addresses some major particle methods for modeling multi-scale and multi-physical problems in engineering and sciences. It contains different particle methods from atomistic scales to continuum scales, with emphasis on molecular dynamics (MD), dissipative particle dynamics (DPD) and smoothed particle hydrodynamics (SPH). This book covers the theoretical background, numerical techniques and many interesting applications of the particle methods discussed in this text, especially in: micro-fluidics and bio-fluidics (e.g., micro drop dynamics, movement and suspension of macro-molecules, cell deformation and migration); environmental and geophysical flows (e.g., saturated and unsaturated flows in porous media and fractures); and free surface flows with possible interacting solid objects (e.g., wave impact, liquid sloshing, water entry and exit, oil spill and boom movement). The presented methodologies, techniques and example applications will benefit students, researchers and professionals in computational engineering and sciences. Contents: Introduction Molecular Dynamics Dissipative Particle Dynamics – Methodology Dissipative Particle Dynamics – Applications Smoothed Particle Hydrodynamics – Methodology Smoothed Particle Hydrodynamics – Applications Three Typical Particle Methods Readership: Undergraduates, graduates, researchers, and professionals studying/dealing with fluid mechanics, numerical analysis and computational mathematics, engineering mechanics, ocean engineering, mechanical engineering. Key Features: The authors have many years of experience in meshfree and particle methods, and are renowned scientists in related areas, with highly cited publications. This can greatly attract fellow researchers from all around the world to probe the latest development on current major particle methods The authors have authored numerous technical publications, and many popular books. They truly understand what the fellow researchers think and want The authors have extensive network in academics and research. It is comparatively easy to introduce the book to professional organizations, international conferences, and different academic bodies such as universities and research institutes Keywords: Computer Modeling; Numerical Methods; Meshfree Particle Methods; Smoothed Particle Hydrodynamics; Dissipative Particle Dynamics; Molecular Dynamics

The numerical treatment of partial differential equations with particle methods and meshfree discretization techniques is a very active research field both in the mathematics and engineering community. Due to their independence of a mesh, particle schemes and meshfree methods can deal with large geometric changes of the domain more easily than classical discretization techniques. Furthermore, meshfree methods offer a promising approach for the coupling of particle models to continuous models. This volume of LNCSE is a collection of the papers from the proceedings of the Second International Workshop on Meshfree Methods held in September 2003 in Bonn. The articles address the different meshfree methods (SPH, PUM, GFEM, EFGM, RKPM, etc.) and their application in applied mathematics, physics and engineering. The volume is intended to foster this new and exciting area of interdisciplinary research and to present recent advances and results in this field.

This book contains 36 articles covering most of the topics in the rapidly developing areas of meshfree methods and extended finite element methods (X-FEM). These topics include domain discretization, boundary discretization, combined domain/boundary discretization, meshfree particle methods, collocation methods, X-FEM, etc. Papers on issues related to implementation and coding of meshfree methods are also presented. The areas of applications of meshfree methods include solving general partial differential equations, the mechanics of solids and structures, smart material/structures, soil-structures, fracture mechanics, fluid dynamics, impact, penetration, micro-fluidics, etc. In addition, techniques for field variable interpolation, such as the moving least squares (MLS) approximation, the point interpolation method (PIM), and radial PIM are reported. Contents: Meshfree Shape Functions for Weak Formulation, Strong Formulation; Meshfree Methods for Smart Materials/Structures; Meshfree Methods for Fracture Analysis; Meshfree Methods for Membranes, Plates & Shells; Meshfree Methods for Soil; Meshfree Methods for CFD; Boundary Meshfree Methods; Coding, Error Estimation, Parallelisation; Meshfree Particle Methods; X-FEM. Readership: Graduate and undergraduate students, researchers, academics, lecturers and engineers in civil engineering, engineering mechanics and mechanical engineering.

Moving Particle Semi-implicit Method: A Meshfree Particle Method for Fluid Dynamics begins by familiarizing the reader with basic theory that supports their journey through sections on advanced MPH methods. The unique insights that this method provides include fluid-structure interaction, non-Newtonian flow, and cavitation, making it relevant to a wide range of applications in the mechanical, structural, and nuclear industries, and in bioengineering. Co-authored by the originator of the MPS method, this book is the most authoritative guide available. It will be of great value to students, academics and researchers in industry. Presents the differences between MPH and SPH, helping readers choose between methods for different purposes Provides pieces of computer code that readers can use in their own simulations Includes the full, extended algorithms Explores the use of MPS in a range of industries and applications, including practical advice

Scattered Data Approximation

Bone Tissue Remodelling Analysis

Conformal Mapping**Extended Finite Element Method****Meshfree Approximation Methods with Matlab****Meshfree Methods for Partial Differential Equations II**

' This is the first-ever book on smoothed particle hydrodynamics (SPH) and its variations, covering the theoretical background, numerical techniques, code implementation issues, and many novel and interesting applications. It contains many appealing and practical examples, including free surface flows, high explosive detonation and explosion, underwater explosion and water mitigation of explosive shocks, high velocity impact and penetration, and multiple scale simulations coupled with the molecular dynamics method. An SPH source code is provided, making this a friendly book for readers and SPH users. Supplementary Materials Software Contents:SPH Concept and Essential FormulationConstructing Smoothing FunctionsSPH for General Dynamic Fluid FlowsDiscontinuous SPH (DSPH)SPH for Simulating ExplosionsSPH for Underwater Explosion Shock SimulationSPH for Hydrodynamics with Material StrengthCoupling SPH with Molecular Dynamics for Multiple Scale SimulationsComputer Implementation of SPH and a 3D SPH Code Readership: Researchers, practitioners, upper-level undergraduates, graduate students, and academics in computational mechanics and engineering. Keywords:Meshfree Method;Meshless Method;SPH;Meshfree Particle Method;Computational Mechanics;Computational Science;Fluid Dynamics;Molecular Dynamics;Multi-Scale Simulations;Explosion;Detonation;High Velocity Impact;PenetrationReviews:"This is a readable book. The presentation of the book is friendly, straightforward, and application oriented ... One of the unique features of the book is its emphasis on the computer implementation and coding of SPH method. Readers can easily learn from the examples illustrated in the book, write their own SPH codes, and test the validity of the numerical method. It may serve as a useful reference book in research and graduate study in computational engineering and science."Computational Mechanics "Numerical simulations using the SPH method are a new area of research, and are still under development. These problems offer ample opportunities for researchers to develop more advanced methods as next generation numerical methods. The book can serve as a good start to efficiently learn, test, practise and develop such new methods."Zentralblatt MATH '

Meshfree methods for the numerical solution of partial differential equations are becoming more and more mainstream in many areas of applications. This volume represents the state-of-the-art in meshfree methods. It consists of articles which address the different meshfree techniques, their mathematical properties and their application in applied mathematics, physics and engineering. The combination of readily available computing power and progress in numerical techniques has made nonlinear systems - the kind that only a few years ago were ignored as too complex - open to analysis for the first time. Now realistic models of living systems incorporating the nonlinear variation and anisotropic nature of physical properties can be solved numerically on modern computers to give realistically usable results. This has opened up new and exciting possibilities for the fusing of ideas from physiology and engineering in the burgeoning new field that is biomechanics. Computational Biomechanics presents pioneering work focusing on the areas of orthopedic and circulatory mechanics, using experimental results to confirm or improve the relevant mathematical models and parameters. Together with two companion volumes, Biomechanics: Functional Adaptation and Remodeling and the Data Book on Mechanical Properties of Living Cells, Tissues, and Organs, this monograph will prove invaluable to those working in fields ranging from medical science and clinical medicine to biomedical engineering and applied mechanics.

The Finite Element Method (FEM) has become an indispensable technology for the modelling and simulation of engineering systems. Written for engineers and students alike, the aim of the book is to provide the necessary theories and techniques of the FEM for readers to be able to use a commercial FEM package to solve primarily linear problems in mechanical and civil engineering with the main focus on structural mechanics and heat transfer. Fundamental theories are introduced in a straightforward way, and state-of-the-art techniques for designing and analyzing engineering systems, including microstructural systems are explained in detail. Case studies are used to demonstrate these theories, methods, techniques and practical applications, and numerous diagrams and tables are used throughout. The case studies and examples use the commercial software package ABAQUS, but the techniques explained are equally applicable for readers using other applications including NASTRAN, ANSYS, MARC, etc. A practical and accessible guide to this complex, yet important subject Covers modeling techniques that predict how components will operate and tolerate loads, stresses and strains in reality

A Practical Course

Advances in Meshfree and X-fem Methods

A Meshfree Particle Method

Volume 20

Meshfree Methods for Partial Differential Equations IV

Advances in Meshfree and X-FEM Methods

Many practical applications require the reconstruction of a multivariate function from discrete, unstructured data. This book gives a self-contained, complete introduction into this subject. It concentrates on truly meshless methods such as radial basis functions, moving least squares, and partitions of unity. The book starts with an overview on typical applications of scattered data approximation, coming from surface reconstruction, fluid-structure interaction, and the numerical solution of partial differential equations. It then leads the reader from basic properties to the current state of research, addressing all important issues, such as existence, uniqueness, approximation properties, numerical stability, and efficient implementation. Each chapter ends with a section giving information on the historical background and hints for further reading. Complete proofs are included, making this perfectly suited for graduate courses on multivariate approximation and it can be used to support courses in computer-aided geometric design, and meshless methods for partial differential equations.

This book offers a collection of 17 scientific papers about the computational modeling of fracture. Some of the manuscripts propose new computational methods and/or how to improve existing cutting edge methods for fracture. These contributions can be classified into two categories: 1. Methods which treat the crack as strong discontinuity such as peridynamics, scaled boundary elements or specific versions of the smoothed finite element methods applied to fracture and 2. Continuous approaches to fracture based on, for instance, phase field models or continuum damage mechanics. On the other hand, the book also offers a wide range of applications where state-of-the-art techniques are employed to solve challenging engineering problems such as fractures in rock, glass, concrete. Also, larger systems such as fracture in subway stations due to fire, arch dams, or concrete decks are studied.

This is an introduction to the mathematical basis of finite element analysis as applied to vibrating systems. Finite element analysis is a technique that is very important in modeling the response of structures to dynamic loads. Although this book assumes no previous knowledge of finite element methods, those who do have knowledge will still find the book to be useful. It can be utilised by aeronautical, civil, mechanical, and structural engineers as well as naval architects. This second edition includes information on the many developments that have taken place over the last twenty years. Existing chapters have been expanded where necessary, and three new chapters have been included that discuss the vibration of shells and multi-layered elements and provide an introduction to the hierarchical finite element method.

Understand How to Use and Develop Meshfree Techniques An Update of a Groundbreaking Work Reflecting the significant advances made in the field since the publication of its predecessor, Meshfree Methods: Moving Beyond the Finite Element Method, Second Edition systematically covers the most widely used meshfree methods. With 70% new material, this edition addresses important new developments, especially on essential theoretical issues. New to the Second Edition Much more details on fundamental concepts and important theories for numerical methods Discussions on special properties of meshfree methods, including stability, convergence, accurate, efficiency, and bound property More detailed discussion on error estimation and adaptive analysis using meshfree methods Developments on combined meshfree/finite element method (FEM) models Comparison studies using meshfree and FEM Drawing on the author's own research, this book provides a single-source guide to meshfree techniques and theories that can effectively handle a variety of complex engineering problems. It analyzes how the methods work, explains how to use and develop the methods, and explores the problems associated with meshfree methods. To access MFree2D (copyright, G. R. Liu), which accompanies MESHFREE METHODS: MOVING BEYOND THE FINITE ELEMENT METHOD, Second Edition

(978-1-4200-8209-8) by Dr. G. R. Liu, please go to the website: www.ase.uc.edu/liugr An access code is needed to use program - to receive it please email Dr. Liu directly at: liugr@ucmail.uc.edu Dr. Liu will reply to you directly with the code, and you can then proceed to use the software.

Moving Beyond the Finite Element Method

Meshfree Methods for Partial Differential Equations

Meshless Methods in Biomechanics

(With CD-ROM)

Finite Element Method

Introduction to Finite Element Vibration Analysis

In recent years meshless/meshfree methods have gained considerable attention in engineering and applied mathematics. The variety of problems that are now being addressed by these techniques continues to expand and the quality of the results obtained demonstrates the effectiveness of many of the methods currently available. The book presents a significant sample of the state of the art in the field with methods that have reached a certain level of maturity while also addressing many open issues. The book collects extended original contributions presented at the Second ECCOMAS Conference on Meshless Methods held in 2007 in Porto. The list of contributors reveals a fortunate mix of highly distinguished authors as well as quite young but very active and promising researchers, thus giving the reader an interesting and updated view of different meshless approximation methods and their range of applications. The material presented is appropriate for researchers, engineers, physicists, applied mathematicians and graduate students interested in this active research area.

Meshless, or meshfree methods, which overcome many of the limitations of the finite element method, have achieved significant progress in numerical computations of a wide range of engineering problems. A comprehensive introduction to meshless methods, Meshless Methods and Their Numerical Properties gives complete mathematical formulations for the most important and classical methods, as well as several methods recently developed by the authors. This book also offers a rigorous mathematical treatment of their numerical properties—including consistency, convergence, stability, and adaptivity—to help you choose the method that is best suited for your needs. Get Guidance for Developing and Testing Meshless Methods Developing a broad framework to study the numerical computational characteristics of meshless methods, the book

presents consistency, convergence, stability, and adaptive analyses to offer guidance for developing and testing a particular meshless method. The authors demonstrate the numerical properties by solving several differential equations, which offer a clearer understanding of the concepts. They also explain the difference between the finite element and meshless methods. Explore Engineering Applications of Meshless Methods The book examines how meshless methods can be used to solve complex engineering problems with lower computational cost, higher accuracy, easier construction of higher-order shape functions, and easier handling of large deformation and nonlinear problems. The numerical examples include engineering problems such as the CAD design of MEMS devices, nonlinear fluid-structure analysis of near-bed submarine pipelines, and two-dimensional multiphysics simulation of pH-sensitive hydrogels. Appendices supply useful template functions, flowcharts, and data structures to assist you in implementing meshless methods. Choose the Best Method for a Particular Problem Providing insight into the special features and intricacies of meshless methods, this is a valuable reference for anyone developing new high-performance numerical methods or working on the modelling and simulation of practical engineering problems. It guides you in comparing and verifying meshless methods so that you can more confidently select the best method to solve a particular problem.

In this popular text for an Numerical Analysis course, the authors introduce several major methods of solving various partial differential equations (PDEs) including elliptic, parabolic, and hyperbolic equations. It covers traditional techniques including the classic finite difference method, finite element method, and state-of-the-art numerical methods. The text uniquely emphasizes both theoretical numerical analysis and practical implementation of the algorithms in MATLAB. This new edition includes a new chapter, Finite Value Method, the presentation has been tightened, new exercises and applications are included, and the text refers now to the latest release of MATLAB. Key Selling Points: A successful textbook for an undergraduate text on numerical analysis or methods taught in mathematics and computer engineering. This course is taught in every university throughout the world with an engineering department or school. Competitive advantage broader numerical methods (including finite difference, finite element, meshless method, and finite volume method), provides the MATLAB source code for most popular PDEs with detailed explanation about the implementation and theoretical analysis. No other existing textbook in the market offers a good combination of theoretical depth and practical source codes.

This important textbook provides an introduction to the concepts of the newly developed extended finite element method (XFEM) for fracture analysis of structures, as well as for other related engineering applications. One of the main advantages of the method is that it avoids any need for remeshing or geometric crack modelling in numerical simulation, while generating discontinuous fields along a crack and around its tip. The second major advantage of the method is that by a small increase in number of degrees of freedom, far more accurate solutions can be obtained. The method has recently been extended to nonlinear materials and other disciplines such as modelling contact and interface, simulation of inclusions and holes, moving and changing phase problems, and even to multiscale analyses. The book is self contained, with summaries of both classical and modern computational techniques. The main chapters include a comprehensive range of numerical examples describing various features of XFEM.

Encyclopedia of Computational Mechanics, 6 Volume Set

With CD-ROM (Volume 2)

Meshless Methods and Their Numerical Properties

This monograph provides a compendium of established and novel error estimation procedures applied in the field of Computational Mechanics. It also includes detailed derivations of these procedures to offer insights into the concepts used to control the errors obtained from employing Galerkin methods in finite and linearized hyperelasticity. The Galerkin methods introduced are considered advanced methods because they remedy certain shortcomings of the well-established finite element method, which is the archetypal Galerkin (mesh-based) method. In particular, this monograph focuses on the systematical derivation of the shape functions used to construct both Galerkin mesh-based and meshfree methods. The mesh-based methods considered are the (conventional) displacement-based, (dual-)mixed, smoothed, and extended finite element methods. In addition, it introduces the element-free Galerkin and reproducing kernel particle methods as representatives of a class of Galerkin meshfree methods. Including illustrative numerical examples relevant to engineering with an emphasis on elastic fracture mechanics problems, this monograph is intended for students, researchers, and practitioners aiming to increase the reliability of their numerical simulations and wanting to better grasp the concepts of Galerkin methods and associated error estimation procedures.

This book covers the fundamentals of continuum mechanics, the integral formulation methods of continuum problems, the basic concepts of finite element methods, and the methodologies, formulations, procedures, and applications of various meshless methods. It also provides general and detailed procedures of meshless analysis on elastostatics, elastodynamics, non-local continuum mechanics and plasticity with a large number of numerical examples. Some basic and important mathematical methods are included in the Appendixes. For readers who want to gain knowledge through hands-on experience, the meshless programs for elastostatics and elastodynamics are provided on an included disc.