Crank Nicolson Solution To The Heat Equation

This book serves as a set of lecture notes for a senior undergraduate level course on the introduction to numerical computation, which was developed through 4 semesters of teaching the course over 10 years. The book requires minimum background knowledge from the students, including only a three-semester of calculus, and a bit on matrices.The book covers many of the introductory topics for a first course in numerical computation, which fits in the short time frame of a semester course. Topics range from polynomial approximations and interpolation, to numerical methods for ODEs and PDEs. Emphasis was made more on algorithm development, basic mathematical ideas behind the algorithms, and the implementation in Matlab.The book is supplemented by two sets of videos, available through the author's YouTube channel. Homework problem sets are provided for each chapter, and complete answer sets are available for instructors upon request.The second edition contains a set of selected advanced topics, written in a self-contained manner, suitable for self-learning or as additional material for an honored version of the course. Videos are also available for these added topics.

Implementing Models of Financial Derivatives is a comprehensive treatment of advanced implementation techniques in VBA for models of financial derivatives. Aimed at readers who are already familiar with the basics of VBA it emphasizes a fully object oriented approach to valuation applications, chiefly in the context of Monte Carlo simulation but also more broadly for lattice and PDE methods. Its unique approach to valuation, emphasizing effective implementation from both the numerical and the computational perspectives makes it an invaluable resource. The book comes with a library of almost a hundred Excel spreadsheets containing implementations of all the methods and models it investigates, including a large number of useful utility procedures. Exercises structured around four application streams supplement the exposition in each chapter, taking the reader from basic procedural level programming up to high level object oriented implementations. Written in eight parts, parts 1-4 emphasize application design in VBA, focused around the development of a plain Monte Carlo application. Part 5 assesses the performance of VBA for this application, and the final 3 emphasize the implementation of a fast and accurate Monte Carlo method for option valuation. Key topics include: ?Fully polymorphic factories in VBA; ?Polymorphic input and output using the TextStream and FileSystemObject objects; ?Valuing a book of options; ?Detailed assessment of the performance of VBA data structures; ?Theory, implementation, and comparison of the main Monte Carlo variance reduction methods; ?Assessment of discretization methods and their application to option valuation in models like CIR and Heston; ?Fast valuation of Bermudan options by Monte Carlo. Fundamental theory and implementations of lattice and PDE methods are presented in appendices and developed through the book in the exercise streams. Spanning the two worlds of academic theory and industrial practice, this book is not only suitable as a classroom text in VBA, in simulation methods, and as an introduction to object oriented design, it is also a reference for model implementers and quants working alongside derivatives groups. Its implementations are a valuable resource for students, teachers and developers alike. Note: CD-ROM/DVD and other supplementary materials are not included as part of eBook file.

The world of quantitative finance (QF) is one of the fastest growing areas of research and its practical applications to derivatives pricing problem. Since the discovery of the famous Black-Scholes equation in the 1970's we have seen a surge in the number of models for a wide range of products such as plain and exotic options, interest rate derivatives, real options and many others. Gone are the days when it was possible to price these derivatives analytically. For most problems we must resort to some kind of approximate method. In this book we employ partial differential equations (PDE) to describe a range of one-factor and multi-factor derivatives products such as plain European and American options, multi-asset options, Asian options, interest rate options and real options. PDE techniques allow us to create a framework for modeling complex and interesting derivatives products. Having defined the PDE problem we then approximate it using the Finite Difference Method (FDM). This method has been used for many application areas such as fluid dynamics, heat transfer, semiconductor simulation and astrophysics, to name just a few. In this book we apply the same techniques to pricing real-life derivative products. We use both traditional (or well-known) methods as well as a number of advanced schemes that are making their way into the QF literature: Crank-Nicolson, exponentially fitted and higher-order schemes for one-factor and multi-factor options Early exercise features and approximation using front-fixing, penalty and variational methods Modelling stochastic volatility models using Splitting methods Critique of ADI and Crank-Nicolson schemes; when they work and when they don't work Modelling jumps using Partial Integro Differential Equations (PIDE) Free and moving boundary value problems in QF Included with the book is a CD containing information on how to set up FDM algorithms, how to map these algorithms to C++ as well as several working programs for one-factor and two-factor models. We also provide source code so that you can customize the applications to suit your own needs.

This book provides a unified and accessible introduction to the basic theory of finite difference schemes applied to the numerical solution *of partial differential equations. Its objective is to clearly present the basic methods necessary to perform finite difference schemes and to understand the theory underlying the schemes.*

Control of Crank-Nicolson Noise in the Numerical Solution of the Heat Conduction Equation

Solution and Interpolation of One-dimensional Heat Equation by Using Crank-nicolson, Cubic Spline and Cubic B-Spline

Numerical Solution of Partial Differential Equations

A Partial Differential Equation Approach

The Numerical Solution of the American Option Pricing Problem

This postgraduate text describes methods which can be used to solve physical and chemical problems on a digital computer. The methods are described on simple, physical problems with which the student is familiar, and then extended to more complex ones. Emphasis is placed on the use of discrete grid points, the representation of derivatives by finite difference ratios, and the consequent replacement of the differential equations by a set of finite difference equations. Efficient methods for the solution of the resulting set of equations are given, and five solution algorithms are presented in the book.

Theory, methods and software for elliptic (steady-state) and parabolic (diffusion) partial differential equations, plus linear algebra and error estimators.

This book focuses on heat and mass transfer, fluid flow, chemical reaction, and other related processes that occur in engineering equipment, the natural environment, and living organisms. Using simple algebra and elementary calculus, the author develops numerical methods for predicting these processes mainly based on physical considerations. Through this approach, readers will develop a deeper understanding of the underlying physical aspects of heat transfer and fluid flow as well as improve their ability to analyze and interpret computed results.

The present paper is meant to describe the finite differences methods necessary to determine the value of financial options. In addition is presented the mathematic model of rating European type options. Value determination of an option is made through solving an equation with derivatives. Finding the analytical solutions is not at hand, reason for which the problem of determining numerical solutions is raised. Next, reference is made to the approximations of model in cause and three methods are intended to be solved: an explicit method, Hyman-Kaplan method and Crank-Nicolson method. As Hyman-Kaplan method is an implicit method, a linear system of equations is obtained whose solution is to be found in LU algorithm. It is also the case of the Crank-Nicolson method whose system of equations finds its solution in Gauss method, Jacobi method, Gauss-Seidel method and the method of successive overrelaxations. Finally, other finite differences methods are reviewed in order to solve the diffusion equation.

Object Oriented Applications with VBA

Finite Difference Methods

A Modern Software Approach

Convergence of the Solution of a Modified Crank-Nicolson Difference Equation to the Solution of a Quasi-linear Parabolic Differential Equation

A Student Introduction

This collection covers new aspects of numerical methods in applied mathematics, engineering, and health sciences. It provides recent theoretical developments and new techniques based on optimization theory, partial differential equations (PDEs), mathematical modeling and fractional calculus that can be used to model and understand complex behavior in natural phenomena. Specific topics covered in detail include new numerical methods for nonlinear partial differential equations, global optimization, unconstrained optimization, detection of HIV- Protease, modelling with new fractional operators, analysis of biological models, and stochastic modelling.

This book presents the theory and applications of Fourier series and integrals, eigenfunction expansions, and related topics, on a level suitable for advanced undergraduates. It includes material on Bessel functions, orthogonal polynomials, and Laplace transforms, and it concludes with chapters on generalized functions and Green's functions for ordinary and partial differential equations. The book deals almost exclusively with aspects of these subjects that are useful in physics and engineering, and includes a wide variety of applications. On the theoretical side, it uses ideas from modern analysis to develop the concepts and reasoning behind the techniques without getting bogged down in the technicalities of rigorous proofs.

Computational Techniques for Differential Equations

This report describes the results of the three-dimensional turbulent boundary-layer calculations performed for the Eurovisc Workshop held in Berlin on 1 April 1982. It is shown that the present method, based on the Crank-Nicolson finite-difference scheme and a simple eddy-viscosity model for turbulence, yields satisfactory results provided regions of viscous-inviscid interaction, which were present in at least three of the four test cases, are avoided. (Author).

Numerical Heat Transfer and Fluid Flow

Methods for the Numerical Solution of Partial Differential Equations

Numerical Solutions of Realistic Nonlinear Phenomena

Numerical Solution for Partial Differential Equations

The Method of Space-time Conservation Element and Solution Element: Development of a New Implicit Solver

What makes this book stand out from the competition is that it is more computational. Once done with both volumes, readers will have the tools to attack a wider variety of problems than those worked out in the competitors' books. The author stresses the use of technology throughout the text, allowing students to utilize it as much as possible.

In a previous paper devoted to the numerical solution of the Stefan problem, the author has proposed a numerical scheme to solve the heat equation on a variable mesh; this scheme is a generalization of the classical Crank-Nicolson scheme since it is identical to the Crank-Nicolson scheme in the particular case of a fixed mesh. Numerical experiments have been performed in one and two space-dimensions, but no mathematical results had been proved. In the present paper, the stability and convergence of the scheme and established together with an error estimate. (Author).

Though it incorporates much new material, this new edition preserves the general character of the book in providing a collection of solutions of the equations of diffusion and describing how these solutions may be obtained.

This well-known 2-volume textbook provides senior undergraduate and postgraduate engineers, scientists and applied mathematicians with the specific techniques, and the framework to develop skills in using the techniques in the various branches of computational fluid dynamics. A solutions manual to the exercises is in preparation.

Numerical Methods for Engineers and Scientists, Second Edition,

Concurrent Implementation of the Crank-Nicolson Method for Heat Transfer Analysis

Introduction to Finite Difference and Finite Element Methods

Stability and Convergence of a Generalized Crank-Nicolson Scheme on a Variable Mesh for the Heat Equation

An Investigation of the Accuracy of Numerical Solutions in the Diffusion Equation for Transient Heat Transfer

This volume brings together selected contributed papers presented at the International Conference of Computational Methods in Science and Engineering (ICCMSE 2006), held in Chania, Greece, October 2006. The conference aims to bring together computational scientists from several disciplines in order to share methods and ideas. The ICCMSE is unique in its kind. It regroups original contributions from all fields of the traditional Sciences, Mathematics, Physics, Chemistry, Biology, Medicine and all branches of Engineering. It would be perhaps more appropriate to define the ICCMSE as a conference on computational science and its applications to science and engineering. Topics of general interest are: Computational Mathematics, Theoretical Physics and Theoretical Chemistry. Computational Engineering and Mechanics, Computational Biology and Medicine, Computational Geosciences and Meteorology, Computational Economics and Finance, Scientific Computation. High Performance Computing, Parallel and Distributed Computing, Visualization, Problem Solving Environments, Numerical Algorithms, Modelling and Simulation of Complex System, Web-based Simulation and Computing, Grid-based Simulation and Computing, Fuzzy Logic, Hybrid Computational Methods, Data Mining, Information Retrieval and Virtual Reality, Reliable Computing, Image Processing, Computational Science and Education etc. More than 800 extended abstracts have been submitted for consideration for presentation in ICCMSE 2005. From these 500 have been selected after international peer review by at least two independent reviewers.

This introduction to finite difference and finite element methods is aimed at graduate students who need to solve differential equations. The prerequisites are few (basic calculus, linear algebra, and ODEs) and so the book will be accessible and useful to readers from a range of disciplines across science and engineering. Part I begins with finite difference methods. Finite element methods are then introduced in Part II. In each part, the authors begin with a comprehensive discussion of one-dimensional problems, before proceeding to consider two or higher dimensions. An emphasis is placed on numerical algorithms, related mathematical theory, and essential details in the implementation, while some useful packages are also introduced. The authors also provide well-tested MATLAB® codes, all available online.

Emphasizing the finite difference approach for solving differential equations, the second edition of Numerical Methods for Engineers and Scientists presents a methodology for systematically constructing individual computer programs. Providing easy access to accurate solutions to complex scientific and engineering problems, each chapter begins with objectives, a discussion of a representative application, and an outline of special features, summing up with a list of tasks students should be able to complete after reading the chapter- perfect for use as a study guide or for review. The AIAA Journal calls the book "...a good, solid instructional text on the basic tools of numerical analysis."

Nonlinear Partial Differential Equations (PDEs) have become increasingly important in the description of physical phenomena. Unlike Ordinary Differential Equations, PDEs can be used to effectively model multidimensional systems. The methods put forward in Discrete Variational Derivative Method concentrate on a new class of "structure-preserving num

European Options Evaluation Through Numerical Method

Numerical Solution of Differential Equations

Crank-Nicolson Method for Evaluation of Solutions of Partial Differential Equations of the Heat Conduction Type

Development, Application and Analysis

The Mathematics of Diffusion

Substantially revised, this authoritative study covers the standard finite difference methods of parabolic, hyperbolic, and elliptic equations, and includes the concomitant theoretical work on consistency, stability, and convergence. The new edition includes revised and greatly expanded sections on stability based on the Lax-Richtmeyer definition, the application of Pade approximants to systems of ordinary differential equations for parabolic and hyperbolic equations, and a considerably improved presentation of iterative methods. A fast-paced introduction to numerical methods, this will be a useful volume for students of mathematics and engineering, and for postgraduates and professionals who need a clear, concise grounding in this discipline.

The early exercise opportunity of an American option makes it challenging to price and an array of approaches have been proposed in the vast literature on this topic. In The Numerical Solution of the American Option Pricing Problem, Carl Chiarella, Boda Kang and Gunter Meyer focus on two numerical approaches that have proved useful for finding all prices, hedge ratios and early exercise boundaries of an American option. One is a finite difference approach which is based on the numerical solution of the partial differential equations with the free boundary problem arising in American option pricing, including the method of lines, the component wise splitting and the finite difference with PSOR. The other approach is the integral transform approach which includes Fourier or Fourier Cosine transforms. Written in a concise and systematic manner, Chiarella, Kang and Meyer explain and demonstrate the advantages and limitations of each of them based on their and their co-workers'' experiences with these approaches over the years. Contents: Introduction; The Merton and Heston Model for a Call; American Call Options under Jump-Diffusion Processes; American Option Prices under Stochastic Volatility and Jump-Diffusion Dynamics OCo The Transform Approach; Representation and Numerical Approximation of American Option Prices under Heston; Fourier Cosine Expansion Approach; A Numerical Approach to Pricing American Call Options under SVJD; Conclusion; Bibliography; Index; About the Authors. Readership: Post-graduates/ Researchers in finance and applied mathematics with interest in numerical methods for American option pricing; mathematicians/physicists doing applied research in option pricing. Key Features: Complete discussion of different numerical methods for American options; Able to handle stochastic volatility and/or jump diffusion dynamics; Able to produce hedge ratios efficiently and accurately"

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.

Definitive Treatment of the Numerical Simulation of Bioheat Transfer and Fluid Flow Motivated by the upwelling of current interest in subjects critical to human health, Advances in Numerical Heat Transfer, Volume 3 presents the latest information on bioheat and biofluid flow. Like its predecessors, this volume assembles a team of renowned international researchers who cover both fundamentals and applications. It explores ingenious modeling techniques and innovative numerical simulation for solving problems in biomedical engineering. The text begins with the modeling of thermal transport by perfusion within the framework of the porous-media theory. It goes on to review other perfusion models, different forms of the bioheat equation for several thermal therapies, and thermal transport in individual blood vessels. The book then describes thermal methods of tumor detection and treatment as well as issues of blood heating and cooling during lengthy surgeries. It also discusses how the enhancement of heat conduction in tumor tissue by intruded nanoparticles improves the efficacy of thermal destruction of the tumor. The final chapters focus on whole-body thermal models, issues concerning the thermal treatment of cancer, and a case study on the thermal ablation of an enlarged prostate.

Computational Techniques for Fluid Dynamics 1

A Structure-Preserving Numerical Method for Partial Differential Equations

Numerical Partial Differential Equations: Finite Difference Methods

Advances in Numerical Heat Transfer

Computational Techniques for Differential Equations

This is a comparison study of the abilities of the eigenvalue method as a numerical method in solving the transient heat conduction equation. The eigenvalue method was compared to five other numerical methods; Runge-Kutta, Gears, extrapolation, fully implicit, and Crank-Nicolson. These methods were used to solved three physical problems. The first is a two dimensional slap which takes advantage of the symmetry of the problem. The second is a the same slap problem without taking advantage of the symmetry. And the third is a cylindrical problem taking full advantage of symmetry. The scope of the study is to see which methods take less computer time while maintaining sufficient accuracy. The time it takes the computer to totally execute the program was used as the time comparison basis. The accuracy is a comparison of the exact solution to the numerical solution. a root mean square average off all the grid points per time step is used. The results of the study were surprising. The accuracy of the eigenvalue method is not any better than that of the Crank-Nicolson method. The computer times show that the eigenvalue is not the fastest for short transient times. A long transient problem with nonlinear terms was not used in this study.

This more-of-physics, less-of-math, insightful and comprehensive book simplifies computational fluid dynamics for readers with little knowledge or experience in heat transfer, fluid dynamics or numerical methods. The novelty of this book lies in the simplification of the level of mathematics in CFD by presenting physical law (instead of the traditional differential equations) and discrete (independent of continuous) math-based algebraic formulations. Another distinguishing feature of this book is that it effectively links theory with computer program (code). This is done with pictorial as well as detailed explanations of implementation of the numerical methodology. It also includes pedagogical aspects such as end-of-chapter problems and carefully designed examples to augment learning in CFD code-development, application and analysis. This book is a valuable resource for students in the fields of mechanical, chemical or aeronautical engineering.

The transient heat conduction equation is solved for inhomogeneous media using the Explicit, Pure-Implicit, Crank-Nicolson and Douglas finite-difference methods, and the numerical solutions are investigated with respect to accuracy and stability. The inherent discontinuity between the initial and boundary conditions is accounted for by mesh refinement. For the two versions of the problem for which the four numerical methods are investigated, all four methods are found to be of equivalent accuracy for small values of the Fourier Modulus. While the Pure-Implicit, Crank-Nicolson and Douglas methods are unconditionally stable, the Crank-Nicolson and Douglas methods are very inaccurate at large values of the Fourier Modulus due to oscillatory behavior. (Author).

This book contains current results of research on numerical solutions of Schrodinger-type problems, sampling theorems, numerical methods for large-scale non-convex quadratic programming, derivative-free algorithms, free material optimization, Moreau's sweeping process and a perspective on industrial mathematics work in recent years. The book also includes wavelet-based digital watermarking techniques and computer simulation of meteorological parameters. One chapter of the book is also devoted to the importance of strange attractors for industrial mathematics. Audience: Academic researchers, as well as researchers working in industry.

With Exercises and Worked Solutions

Calculations of Three-dimensional Turbulent Boundary Layers Using the Crank-Nicolson Method

Introduction to Computational Fluid Dynamics

Fourier Analysis and Its Applications

A Comparison Study of the Eigenvalue Method for the Solution of the Transient Heat Conduction Equation

This book is intended to determine the stability of one space dimension diffusion equation. A Matlab code of finite difference methods with increment of time-space was used in which the behaviour of the errors was observed from the graphs. The explicit scheme was stable with Dirichlet boundary condition when considering space for r less than or equal to 0.5. It was observed that as the gradient alpha of temperature decreases with derivative boundary conditions, the interval of r for the explicit scheme stet stable decreases from the values r less than or equal to 0.5 corresponding to Dirichlet boundary conditions. When the term with coefficient gamma is added to the PDE, explicit scheme becomes stable depending to the value of gamma. The Crank-Nicolson and semi-analytic schemes were stable with both Dirichlet boundary conditions and derivative boundary conditions for all r. It was observed that the Crank-Nicolson scheme was accurate than explicit scheme. The semi-analytic method has only one source of error, the space discretization also it is able to solve for a vector of time simultaneously. But with sufficient small r all three methods were performed well.

Basic option theory - Numerical methods - Further option theory - Interest rate derivative products.

Procedures and results are given for the numerical solution of viscous compressible flow in a slender channel. The results are compared with an exact solution developed through similarity. Two methods, normal implicit method and Crank-Nicolson method, were attempted in the numerical solution. The Crank-Nicolson method was found to be superior to the normal implicit method. The normal implicit method did have the advantage of requiring less computation time since the momentum and energy equations were solved separately by two sets of (N-2) equations with (N-2) unknowns. The normal implicit method also made possible the use of a smaller transverse grid size.

This investigation compares the accuracy obtained using two implicit finite difference representations of the partial differential equation for transient heat conduction to obtain solutions to two basic conduction problems. The two repre sentations considered are the Crank-Nicolson form and a theoretically more optimum form designated as the Optimum Implicit form. It is demonstrated that the major source of error occurs at the initial time/space node of the difference mesh. By decreasing this error, the Optimum Implicit form is shown to be as accurate as the Crank-Nicolson form in one problem, and considerably more accurate in the second. (Author).

Introduction To Numerical Computation, An (Second Edition)

Fundamental and General Techniques

Implementing Models of Financial Derivatives

Finite Difference Schemes and Partial Differential Equations

Discrete Variational Derivative Method

This book is open access under a CC BY 4.0 license. This easy-to-read book introduces the basics of solving partial differential equations by means of finite difference methods. Unlike many of the traditional academic works on the topic, this book was written for practitioners. Accordingly, it especially addresses: the construction of finite difference schemes, formulation and implementation of algorithms, verification of implementations, analyses of physical behavior as implied by the numerical solutions, and how to apply the methods and software to solve problems in the fields of physics ar biology.

A Numerical Solution of Viscous Compressible Flow in Slender Channels

A Comparison of Finite-Difference Methods for the Solution of the Transient Heat Conduction Equation in Inhomogeneous Media

Trends in Industrial and Applied Mathematics

Finite Difference Computing with PDEs

Recent Progress in Computational Sciences and Engineering (2 vols)