Quasilinearization approach to nonlinear problems in physics with application to nonlinear ODEs

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Abstract

The general conditions under which the quadratic, uniform and monotonic convergence in the quasilinearization method of solving nonlinear ordinary differential equations could be proved are formulated and elaborated. The generalization of the proof to partial differential equations is straightforward. The method, whose mathematical basis in physics was discussed recently by one of the present authors (VBM), approximates the solution of a nonlinear differential equation by treating the nonlinear terms as a perturbation about the linear ones, and unlike perturbation theories is not based on the existence of some kind of a small parameter.

It is shown that the quasilinearization method gives excellent results when applied to different nonlinear ordinary differential equations in physics, such as the Blasius, Duffing, Lane–Emden and Thomas–Fermi equations. The first few quasilinear iterations already provide extremely accurate and numerically stable answers. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

In a series of recent papers [1,2], the possibility of applying a very powerful approximation technique called the quasilinearization method (QLM) to physical problems has been discussed. The QLM is designed to confront the nonlinear aspects of physical processes. The method, whose iterations are constructed to yield rapid convergence and often monotonicity, was originally introduced forty years ago by Bellman and Kalaba [3,4] as a generalization of the Newton–Raphson method [5,6] to solve individual or systems of nonlinear ordinary and partial differential equations. Modern developments and applications of the QLM to different fields are given in a monograph [7].

However, the QLM was never systematically studied or extensively applied in physics, although references to it can be found in well-known monographs [8,9] dealing with the variable phase approach to potential scattering, as well as in a few scattered research papers [10–13]. The reason for the sparse use of the QLM in Physics is that the convergence of the method has been proven only under rather restrictive conditions [3,4], which generally

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Nonlinear Processes in Engineering ,1974-09-20 In this book we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems A number of computing techniques are considered such as methods of operator approximation with any given accuracy operator interpolation techniques including a non Lagrange interpolation methods of system representation subject to constraints associated with concepts of causality memory and stationarity methods of system representation with an accuracy that is the best within a given class of models methods of covariance matrix estimation methods for low rank matrix approximations hybrid methods based on a combination of iterative procedures and best operator approximation andmethods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory As a result the book represents a blend of new methods in general computational analysis and specific but also generic techniques for study of systems theory ant its particularbranches such as optimal filtering and information compression Best operator approximation Non Lagrange interpolation Generic Karhunen Loeve transform Generalised low rank matrix approximation Optimal data compression Optimal nonlinear filtering **Computational Methods in Engineering Boundary Value Problems** T.Y. Na,1980-01-18 Computational Methods in Engineering Boundary Value Problems **Mathematical Methods XIB** Douglas Henderson,2012-12-02 Physical Chemistry An Advanced Treatise Volume XIB Mathematical Methods focuses on mathematical techniques that consist of concepts relating to differentiation and integration This book discusses the methods in lattice statistics Pfaffian solution of the planar Ising problem and probability theory and stochastic processes The random variables and probability distributions non equilibrium problems Brownian motion and scattering theory are also elaborated This text likewise covers the elastic scattering from atoms solution of integral and differential equations concepts in graph theory and theory of operator equations This volume provides graduate and physical chemistry students a basic understanding of mathematical techniques important in chemistry **Transition in Turbines** ,1985 **Selected Water Resources Abstracts** ,1970 *Foundations of Applied Mathematics* Michael D. Greenberg,2013-11-26 Classic text reference suitable for undergraduate and graduate engineering students Topics include real variable theory complex variables linear analysis partial and ordinary differential equations and other subjects Includes answers to selected exercises 1978 edition **Numerical Solution of Integral Equations** Michael A. Golberg,2013-11-11 In 1979 I edited Volume 18 in this series Solution Methods for Integral Equations Theory and Applications Since that time there has been an explosive growth in all aspects of the numerical solution of integral equations By my estimate over 2000 papers on this subject have been published in the last decade and more than 60 books on theory and applications have appeared In particular as can be

seen in many of the chapters in this book integral equation techniques are playing an increas ingly important role in the solution of many scientific and engineering problems For instance the boundary element method discussed by Atkinson in Chapter 1 is becoming an equal partner with finite element and finite difference techniques for solving many types of partial differential equations Obviously in one volume it would be impossible to present a complete picture of what has taken place in this area during the past ten years Consequently we have chosen a number of subjects in which significant advances have been made that we feel have not been covered in depth in other books For instance ten years ago the theory of the numerical solution of Cauchy singular equations was in its infancy Today as shown by Golberg and Elliott in Chapters 5 and 6 the theory of polynomial approximations is essentially complete although many details of practical implementation remain to be worked out   *Guide to the Literature of Engineering, Mathematics, and the Physical Sciences* Sylvia Weiser,1972   *Applied Mechanics Reviews* ,1970   Catalog of the United States Geological Survey Library U.S. Geological Survey Library,1972   *Developments in Theoretical and Applied Mechanics* ,1978   **NASA Contractor Report** ,1982   Catalog of Copyright Entries. Third Series Library of Congress. Copyright Office,1972   **SIAM Journal on Applied Mathematics** ,1970   **NASA Conference Publication** ,1985   **Mathematical Physiology; Blood Flow and Electrically Active Cells** H. Melvin Lieberstein,1973   **Proceedings** National Academy of Sciences, India,2008   **American Book Publishing Record** ,1970

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