



## Optimal Quadrature Rules for Numerical Solution of the Nonlinear Fredholm Integral Equations

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**Abstract.** In this paper, an iterative method of successive approximations to the approximate solutions of nonlinear Hammerstein- Fredholm integral equations using an optimal quadrature formula for classes of functions of Lipschitz types is provided. Also, the convergence analysis and numerical stability of the proposed method are proved. Finally, some numerical examples verify the theoretical results and show the accuracy of the method.

### 1. Introduction

In this investigation, we propose a numerical method for the following nonlinear Hammerstein- Fredholm integral equation of the second kind

$$x(t) = f(t) + A \int_a^b K(t, s)g(s, x(s))ds, \quad t \in [a, b], \quad (1)$$

where  $x(t)$  is an unknown function on  $[a, b]$  and also,  $f(t)$ ,  $K(t, s)$  are known functions on  $[a, b]$ ,  $[a, b] \times [a, b]$ , respectively.

The mathematical modeling of physical phenomena, many problems in applied mathematics, engineering, mechanics, mathematical physics and many other fields can be transformed into the second-kind of integral equations [8, 11, 15, 21, 22, 24]. There are many numerical methods for solving these equations. The Galerkin and collocation methods are the two commonly used methods for the numerical solutions of these equations [2, 9]. Numerical solutions of linear and nonlinear integral equations have been presented, including, block-pulse functions (BPFs)[7, 17], degenerate kernel method [1], triangular functions (TFs)[10], Chebyshev polynomials [31], Taylor-series expansion method [16], Least squares approximation method[28], operational matrices [27], Bernoulli polynomials [4], B-spline wavelets [19] and wavelet method [13, 20]. Classical theorems on the existence and uniqueness of the solution of nonlinear integral equations can be found in [11, 29]. Existence results for functional integral equations are obtained using the measure of noncompactness and Darbo conditions in [14] and [18] respectively. The method of

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# Optimal Solution Of Nonlinear Equations

**André Girard**

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Specifically the book proposes Lyapunov based EMPC methods for nonlinear systems two tier EMPC architectures that are highly computationally efficient and EMPC schemes handling explicitly uncertainty time varying cost functions time delays and multiple time scale dynamics The proposed methods employ a variety of tools ranging from nonlinear systems analysis through Lyapunov based control techniques to nonlinear dynamic optimization The applicability and performance of the proposed methods are demonstrated through a number of chemical process examples The book presents state of the art methods for the design of economic model predictive control systems for chemical processes In addition to being mathematically rigorous these methods accommodate key practical issues for example direct optimization of process economics time varying economic cost functions and computational efficiency Numerous comments and remarks providing fundamental understanding of the merging of process economics and feedback control into a single framework are included A control engineer can easily tailor the many detailed examples of industrial relevance given within the text to a specific application The authors present a rich collection of new research topics and references to significant recent work making Economic Model Predictive Control an important source of information and inspiration for academics and graduate students researching the area and for process engineers interested in applying its ideas *Handbook of Algorithms for Physical Design Automation* Charles J. Alpert,Dinesh P. Mehta,Sachin S. Sapatnekar,2008-11-12 The physical design flow of any project depends upon the size of the design the technology the number of designers the clock frequency and the time to do the design As technology advances and design styles change physical design flows are constantly reinvented as traditional phases are removed and new ones are added to accommodate changes in *Applied Mechanics Reviews* ,1980

*Numerical Methods for Unconstrained Optimization and Nonlinear Equations* J. E. Dennis, Jr.,Robert B. Schnabel,1996-12-01 A complete state of the art description of the methods for unconstrained optimization and systems of nonlinear equations *ASME Technical Papers* ,1983 *Precision Engineering and Non-Traditional Machining* Jian Hua Wang,Chang Fu Zhang,Xiao Li Jin,Jin Long Zou,2011-11-29 Selected peer reviewed papers from the 2011 International Conference on Precision Engineering and Non Traditional Machining PENTM 2011 December 9 11 2011 Xi an China *SSRI Workshop Series* ,1961 **IEEE/SICE/RSJ International Conference on Multisensor Fusion and Integration for Intelligent Systems** ,1999 **Routing and Dimensioning in Circuit-switched Networks** André Girard,1990 **Government Reports Announcements & Index** ,1988-11 *International Aerospace Abstracts* ,1980

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