

Approximation of large-scale dynamical systems: An overview^{*†}

A.C. Antoulas[‡] and D.C. Sorensen[§]

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Abstract

In this paper we review the state of affairs in the area of approximation of large-scale systems. We distinguish among three basic categories, namely the **SVD**-based, the **Krylov**-based and the **SVD-Krylov**-based approximation methods. The first two were developed independently of each other and have distinct sets of attributes and drawbacks. The third approach seeks to combine the best attributes of the first two.

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1 Introduction and problem statement

Differential equations are one of the most successful means of modeling dynamical systems. In this paper we will deal with the problem of *simplification* or *model reduction* of dynamical systems described by differential equations. Model reduction has a long history in the systems and control literature. In fact, the general topic of dimension reduction in dynamical systems is pervasive in the applied mathematics literature. The systems we will

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[‡]Dept. of Electrical and Computer Engineering, Rice University, Houston, TX 77005-1892 (aca@ece.rice.edu)

[§]Dept. of Computational and Applied Mathematics, Rice University, Houston, TX 77005-1892 (sorensen@caam.rice.edu)

Approximation Of Large Scale Dynamical S

**Maurizio Falcone, Roberto Ferretti, Lars
Grüne, William M. McEneaney**

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Approximation of Large-Scale Dynamical Systems Athanasios C. Antoulas, 2009-06-25 Mathematical models are used to simulate and sometimes control the behavior of physical and artificial processes such as the weather and very large scale integration VLSI circuits The increasing need for accuracy has led to the development of highly complex models However in the presence of limited computational accuracy and storage capabilities model reduction system approximation is often necessary Approximation of Large Scale Dynamical Systems provides a comprehensive picture of model reduction combining system theory with numerical linear algebra and computational considerations It addresses the issue of model reduction and the resulting trade offs between accuracy and complexity Special attention is given to numerical aspects simulation questions and practical applications

Computational Methods for Approximation of Large-Scale Dynamical Systems

Mohammad Monir Uddin, 2019-04-30 These days computer based simulation is considered the quintessential approach to exploring new ideas in the different disciplines of science engineering and technology SET To perform simulations a physical system needs to be modeled using mathematics these models are often represented by linear time invariant LTI continuous time CT systems Oftentimes these systems are subject to additional algebraic constraints leading to first or second order differential algebraic equations DAEs otherwise known as descriptor systems Such large scale systems generally lead to massive memory requirements and enormous computational complexity thus restricting frequent simulations which are required by many applications To resolve these complexities the higher dimensional system may be approximated by a substantially lower dimensional one through model order reduction MOR techniques Computational Methods for Approximation of Large Scale Dynamical Systems discusses computational techniques for the MOR of large scale sparse LTI CT systems Although the book puts emphasis on the MOR of descriptor systems it begins by showing and comparing the various MOR techniques for standard systems The book also discusses the low rank alternating direction implicit LR ADI iteration and the issues related to solving the Lyapunov equation of large scale sparse LTI systems to compute the low rank Gramian factors which are important components for implementing the Gramian based MOR Although this book is primarily aimed at post graduate students and researchers of the various SET disciplines the basic contents of this book can be supplemental to the advanced bachelor s level students as well It can also serve as an invaluable reference to researchers working in academics and industries alike Features Provides an up to date step by step guide for its readers Each chapter develops theories and provides necessary algorithms worked examples numerical experiments and related exercises With the combination of this book and its supplementary materials the reader gains a sound understanding of the topic The MATLAB codes for some selected algorithms are provided in the book The solutions to the exercise problems experiment data sets and a digital copy of the software are provided on the book s website The numerical experiments use real world data sets obtained from industries and research institutes

Model Reduction of Parametrized Systems Peter Benner, Mario

Ohlberger,Anthony Patera,Gianluigi Rozza,Karsten Urban,2017-09-05 The special volume offers a global guide to new concepts and approaches concerning the following topics reduced basis methods proper orthogonal decomposition proper generalized decomposition approximation theory related to model reduction learning theory and compressed sensing stochastic and high dimensional problems system theoretic methods nonlinear model reduction reduction of coupled problems multiphysics optimization and optimal control state estimation and control reduced order models and domain decomposition methods Krylov subspace and interpolatory methods and applications to real industrial and complex problems The book represents the state of the art in the development of reduced order methods It contains contributions from internationally respected experts guaranteeing a wide range of expertise and topics Further it reflects an important effort carried out over the last 12 years to build a growing research community in this field Though not a textbook some of the chapters can be used as reference materials or lecture notes for classes and tutorials doctoral schools master classes

Numerical Methods for Optimal Control Problems Maurizio Falcone,Roberto Ferretti,Lars Grüne,William M. McEneaney,2019-01-26 This work presents recent mathematical methods in the area of optimal control with a particular emphasis on the computational aspects and applications Optimal control theory concerns the determination of control strategies for complex dynamical systems in order to optimize some measure of their performance Started in the 60 s under the pressure of the space race between the US and the former USSR the field now has a far wider scope and embraces a variety of areas ranging from process control to traffic flow optimization renewable resources exploitation and management of financial markets These emerging applications require more and more efficient numerical methods for their solution a very difficult task due the huge number of variables The chapters of this volume give an up to date presentation of several recent methods in this area including fast dynamic programming algorithms model predictive control and max plus techniques This book is addressed to researchers graduate students and applied scientists working in the area of control problems differential games and their applications

System-level Modeling of MEMS Oliver Brand,Gary K. Fedder,Christofer Hierold,Jan G. Korvink,Osamu Tabata,2012-12-20 System level modeling of MEMS microelectromechanical systems comprises integrated approaches to simulate understand and optimize the performance of sensors actuators and microsystems taking into account the intricacies of the interplay between mechanical and electrical properties circuitry packaging and design considerations Thereby system level modeling overcomes the limitations inherent to methods that focus only on one of these aspects and do not incorporate their mutual dependencies The book addresses the two most important approaches of system level modeling namely physics based modeling with lumped elements and mathematical modeling employing model order reduction methods with an emphasis on combining single device models to entire systems At a clearly understandable and sufficiently detailed level the readers are made familiar with the physical and mathematical underpinnings of MEMS modeling This enables them to choose the adequate methods for the respective application needs

This work is an invaluable resource for all materials scientists electrical engineers scientists working in the semiconductor and or sensor industry physicists and physical chemists

Applications Peter Benner,et al.,2020-12-07 An increasing complexity of models used to predict real world systems leads to the need for algorithms to replace complex models with far simpler ones while preserving the accuracy of the predictions This three volume handbook covers methods as well as applications This third volume focuses on applications in engineering biomedical engineering computational physics and computer science

OPTIROB 2013 Adrian Olaru,2013-07-15 Selected peer reviewed papers from the OPTIROB2013 International Conference on Biomechanics Neurorehabilitation Mechanical Engineering Manufacturing Systems Robotics and Aerospace Optimization of the Engineering Systems June 20 23 2013 Mamaia Constanta Romania

SIAM Journal on Matrix Analysis and Applications ,2005 SIAM Journal on Scientific Computing ,2009 *The Atmosphere and Climate of Mars* Robert M. Haberle,R. Todd Clancy,François Forget,Michael D. Smith,Richard W. Zurek,2017-06-29 This volume reviews all aspects of Mars atmospheric science from the surface to space and from now and into the past

Applied Parallel Computing ,2004 **International Journal of Applied Mathematics and Computer Science** ,2001

Symposium International Astronomical Union,1953 **The Industrial Chemist and Chemical Manufacturer** ,1930

Preprints of Papers for IFAC Kyoto Symposium on Systems Engineering Approach to Computer Control ,1970

Astrophysical and Geophysical Flows as Dynamical Systems Neil J. Balmforth,1999 Astrophysical and Geophysical Flows as Dynamical Systems was the theme of the 1998 GFD Summer Program With Antonello Provenzale at the helm we sailed headlong into the nonlinear world of astrophysical and geophysical fluid mechanics Simultaneously Charles Tresser gave several energetic presentations surrounding the dynamics of circle maps Unfortunately our third planned speaker John David Crawford fell ill just prior to the program and could not participate Sadly John David passed away later in the summer We will remember him at GFD from the excellent lectures he gave at the cottage during the summer of 1993 In a departure from usual practice and in an effort to lend more coherence to the at times very wide ranging topics discussed at Walsh GFD

The Dynamical Theory of the Formation of the Earth, Based on the Assumption of Its Nonrotation During the Whole Period Called "the Beginning" Archibald Tucker Ritchie,1873 Industrial Chemist and Chemical Manufacturer ,1930

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