MathWorks

Modeling Dynamic Systems
with MATLAB and Simulink

Model Structures
Use MATLAB® and Simulink® to support linear and nonlinear model structures, including integration of third-party models.

Linear Models

TRANSFER FUNCTION

STATE SPACE
$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

LINEAR PARAMETER VARYING

TIME SERIES (ARX, ARMA)

FREQUENCY RESPONSE DATA

ZPK

Nonlinear Models

ODEs

Nonlinear portion could be represented with AI

HAMMERSTEIN-WIENER

NEURAL STATE SPACE

NLARX

AI-BASED MODELS

GAUSSIAN PROCESS

SUPPORT VECTOR MACHINE

REGRESSION TREE

NEURAL NETWORK

Integrate Third-Party Models

FUNCTIONAL MOCKUP UNIT

PYTHON IMPORTERS

S-FUNCTIONS

Model Parameters
Determine model parameters through first principles, grey box, and data-driven methods.

MODELING BASED ON PHYSICAL LAWS

MODELING BASED ON SYSTEM DATA

WHITE BOX — **GREY BOX** — **BLACK BOX**

FIRST PRINCIPLES
$$f(x, t) = m\ddot{x}$$

PHYSICAL MODELING WITH SIMSCAPE

GREY BOX ODEs

PARAMETER ESTIMATION IN SIMULINK MODELS

PARAMETER ESTIMATION

SYSTEM IDENTIFICATION (TRADITIONAL AND AI-BASED)

SYSTEM IDENTIFICATION

DATA PREPARATION

ONLINE ESTIMATION

OFFLINE ESTIMATION

MODEL ANALYSIS

Model Manipulation
Modify models through transformation, linearization, and order reduction methods.

Model Transformation

MODEL TYPE

CONTINUOUS-DISCRETE
$$f(s) \leftrightarrow f(z)$$

STATE-COORDINATE

MODAL DECOMPOSITION

Linearization

NUMERICAL PERTURBATION

BLOCK-BY-BLOCK

FREQUENCY RESPONSE ESTIMATION

MODEL LINEARIZER

Reduced Order Modeling

MODEL-BASED

DATA-DRIVEN
Use model data to learn a linear order model

BALANCED TRUNCATION

MODEL REDUCER

POLE-ZERO SIMPLIFICATION

REDUCED ORDER MODELING

Computer Simulation Of Dynamic Systems

O García

Computer Simulation Of Dynamic Systems:

   Computer Simulation of Dynamic Systems Maurice F. Aburdene,1999   Computer Simulation of Dynamic Systems
Ralph J. Kochenburger,1972 Fundamental simulation techniques an example Basic principles of analog computers Linear
simulation operations with digital computers Nonlinear operations with analog computers Implicit methods of function
generation Simulation of discontinuous relations Boundary value problems Optimization of simulated systems Simulation of
random disturbances and their effects Implementation of distributed parameter systems partial differential equations Parallel
and serial computation hybrid computers   **Computer Simulation of Dynamic Systems** Charles G. Smith,1987
      Computer Modeling and Simulation of Dynamic Systems Using Wolfram SystemModeler Kirill
Rozhdestvensky,Vladimir Ryzhov,Tatiana Fedorova,Kirill Safronov,Nikita Tryaskin,Shaharin Anwar Sulaiman,Mark
Ovinis,Suhaimi Hassan,2020-03-20 This book briefly discusses the main provisions of the theory of modeling It also describes
in detail the methodology for constructing computer models of dynamic systems using the Wolfram visual modeling
environment SystemModeler and provides illustrative examples of solving problems of mechanics and hydraulics Intended for
students and professionals in the field the book also serves as a supplement to university courses in modeling and simulation
of dynamic systems   **Measurements, Modelling and Simulation of Dynamic Systems** Edward Layer,Krzysztof
Tomczyk,2009-12-30 The development and use of models of various objects is becoming a more common practice in recent
days This is due to the ease with which models can be developed and examined through the use of computers and
appropriate software Of those two the former high speed computers are easily accessible nowadays and the latter existing
programs are being updated almost continuously and at the same time new powerful software is being developed Usually a
model represents correlations between some processes and their interactions with better or worse quality of representation
It details and characterizes a part of the real world taking into account a structure of phenomena as well as quantitative and
qualitative relations There are a great variety of models Modelling is carried out in many diverse fields All types of natural
phenomena in the area of biology ecology and medicine are possible subjects for modelling Models stand for and represent
technical objects in physics chemistry engineering social events and behaviours in sociology financial matters investments
and stock markets in economy strategy and tactics defence security and safety in military fields There is one common point
for all models We expect them to fulfil the validity of prediction It means that through the analysis of models it is possible to
predict phenomena which may occur in a fragment of the real world represented by a given model We also expect to be able
to predict future reactions to signals from the outside world   **Simulation** John McLeod,1968   **Interactive
Dynamic-System Simulation** Granino A. Korn,2016-04-19 Showing you how to use personal computers for modeling and
simulation Interactive Dynamic System Simulation Second Edition provides a practical tutorial on interactive dynamic system
modeling and simulation It discusses how to effectively simulate dynamical systems such as aerospace vehicles power plants

chemical processes control systems and physiological systems Written by a pioneer in simulation the book introduces dynamic system models and explains how software for solving differential equations works After demonstrating real simulation programs with simple examples the author integrates a new treatment of the difference equation programs needed to model sampled data control systems with digital controllers Subsequent chapters provide detailed programming know how These chapters cover library table lookup user definable limiter switching and noise functions an experiment protocol scripting language powerful vector and matrix operations and classical simulation programs that illustrate a number of useful programming tricks The final chapter shows how experiment protocol scripts and compiled DYNAMIC program segments can quickly solve mathematical problems including fast graph plotting Fourier transforms and complex number plots Downloadable ResourcesThe accompanying downloadable resources contain a complete industrial strength simulation program package To install the ready to run simulation system simply copy a single Windows or Linux folder from the downloadable resources You can then run and modify every program example in the text or try your own projects For truly interactive modeling screen edited programs are run time compiled and immediately produce solution displays on a typed run command   Dynamic Modeling Bruce Hannon,Matthias Ruth,2014-01-15   **Dynamic Systems Biology Modeling and Simulation** Joseph DiStefano III,2015-01-10 Dynamic Systems Biology Modeling and Simuation consolidates and unifies classical and contemporary multiscale methodologies for mathematical modeling and computer simulation of dynamic biological systems from molecular cellular organ system on up to population levels The book pedagogy is developed as a well annotated systematic tutorial with clearly spelled out and unified nomenclature derived from the author s own modeling efforts publications and teaching over half a century Ambiguities in some concepts and tools are clarified and others are rendered more accessible and practical The latter include novel qualitative theory and methodologies for recognizing dynamical signatures in data using structural multicompartmental and network models and graph theory and analyzing structural and measurement data models for quantification feasibility The level is basic to intermediate with much emphasis on biomodeling from real biodata for use in real applications Introductory coverage of core mathematical concepts such as linear and nonlinear differential and difference equations Laplace transforms linear algebra probability statistics and stochastics topics The pertinent biology biochemistry biophysics or pharmacology for modeling are provided to support understanding the amalgam of math modeling with life sciences Strong emphasis on quantifying as well as building and analyzing biomodels includes methodology and computational tools for parameter identifiability and sensitivity analysis parameter estimation from real data model distinguishability and simplification and practical bioexperiment design and optimization Companion website provides solutions and program code for examples and exercises using Matlab Simulink VisSim SimBiology SAAMII AMIGO Copasi and SBML coded models A full set of PowerPoint slides are available from the author for teaching from his textbook He uses them to teach a 10 week quarter upper division course at UCLA which meets

twice a week so there are 20 lectures They can easily be augmented or stretched for a 15 week semester course Importantly the slides are editable so they can be readily adapted to a lecturer s personal style and course content needs The lectures are based on excerpts from 12 of the first 13 chapters of DSBMS They are designed to highlight the key course material as a study guide and structure for students following the full text content The complete PowerPoint slide package 25 MB can be obtained by instructors or prospective instructors by emailing the author directly at joed cs ucla edu **Dynamic Modeling** Bruce M. Hannon,Matthias Ruth,1994 Dynamic Modeling introduces an approach to modeling that makes it a more practical intuitive endeavour The book enables readers to convert their understanding of a phenomenon to a computer model and then to run the model and let it yield the inevitable dynamic consequences built into the structure of the model Part I provides an introduction to modeling dynamic systems while Part II offers general methods for modeling Parts III through to VIII then apply these methods to model real world phenomena from chemistry genetics ecology economics and engineering To develop and execute dynamic simulation models Dynamic Modeling comes with STELLA II run time software for Windows based computers as well as computer files of sample models used in the book A clear approachable introduction to the modeling process of interest in any field where real problems can be illuminated by computer simulation **Modeling of Dynamic Systems** Lennart Ljung,Torkel Glad,1994 Written by a recognized authority in the field of identification and control this book draws together into a single volume the important aspects of system identification AND physical modelling KEY TOPICS Explores techniques used to construct mathematical models of systems based on knowledge from physics chemistry biology etc e g techniques with so called bond graphs as well those which use computer algebra for the modeling work Explains system identification techniques used to infer knowledge about the behavior of dynamic systems based on observations of the various input and output signals that are available for measurement Shows how both types of techniques need to be applied in any given practical modeling situation Considers applications primarily simulation MARKET For practicing engineers who are faced with problems of modeling *Interactive Digital Computer Simulation of Dynamical Systems* Michael Charles Revett,1976 Advanced Dynamic-system Simulation Granino A. Korn,2007-03-07 Learn the latest techniques in programming sophisticated simulation systems This cutting edge text presents the latest techniques in advanced simulation programming for interactive modeling and simulation of dynamic systems such as aerospace vehicles control systems and biological systems The author a leading authority in the field demonstrates computer software that can handle large simulation studies on standard personal computers Readers can run edit and modify the sample simulations from the text with the accompanying CD ROM featuring the OPEN DESIRE program for Linux and Windows The program included on CD solves up to 40 000 ordinary differential equations and implements exceptionally fast and convenient vector operations The text begins with an introduction to dynamic system simulation including a demonstration of a simple guided missile simulation Among the other highlights of coverage are Models that involve sampled data operations and sampled data

difference equations including improved techniques for proper numerical integration of switched variables Novel vector compiler that produces exceptionally fast programs for vector and matrix assignments differential equations and difference equations Application of vector compiler to parameter influence studies and Monte Carlo simulation of dynamic systems Vectorized Monte Carlo simulations involving time varying noise derived from periodic pseudorandom noise samples Vector models of neural networks including a new pulsed neuron model Vectorized programs for fuzzy set controller partial differential equations and agro ecological models replicated at many points of a landscape map This text is intended for graduate level students engineers and computer scientists particularly those involved in aerospace control system design chemical process control and biological systems All readers will gain the practical skills they need to design sophisticated simulations of dynamic systems Note CD ROM DVD and other supplementary materials are not included as part of eBook file

  System Dynamics Dean C. Karnopp,Donald L. Margolis,Ronald C. Rosenberg,2012-03-07 An expanded new edition of the bestselling system dynamics book using the bond graph approach A major revision of the go to resource for engineers facing the increasingly complex job of dynamic systems design System Dynamics Fifth Edition adds a completely new section on the control of mechatronic systems while revising and clarifying material on modeling and computer simulation for a wide variety of physical systems This new edition continues to offer comprehensive up to date coverage of bond graphs using these important design tools to help readers better understand the various components of dynamic systems Covering all topics from the ground up the book provides step by step guidance on how to leverage the power of bond graphs to model the flow of information and energy in all types of engineering systems It begins with simple bond graph models of mechanical electrical and hydraulic systems then goes on to explain in detail how to model more complex systems using computer simulations Readers will find New material and practical advice on the design of control systems using mathematical models New chapters on methods that go beyond predicting system behavior including automatic control observers parameter studies for system design and concept testing Coverage of electromechanical transducers and mechanical systems in plane motion Formulas for computing hydraulic compliances and modeling acoustic systems A discussion of state of the art simulation tools such as MATLAB and bond graph software Complete with numerous figures and examples System Dynamics Fifth Edition is a must have resource for anyone designing systems and components in the automotive aerospace and defense industries It is also an excellent hands on guide on the latest bond graph methods for readers unfamiliar with physical system modeling   **Simulation of Dynamic Systems with MATLAB and Simulink** Harold Klee,2018-10-03 Simulation is increasingly important for students in a wide variety of fields from engineering and physical sciences to medicine biology economics and applied mathematics Current trends point toward interdisciplinary courses in simulation intended for all students regardless of their major but most textbooks are subject specific and consequen   *Modeling and Simulation of Complex Dynamical Systems* Vladimir Ryzhov,Tatiana Fedorova,Kirill Safronov,Shaharin Anwar Sulaiman,Mark

Ovinis,Veeradasan Perumal,2021-08-20 This book highlights the practical aspects of computer modelling and simulation of complex dynamical systems for students Mechanical systems are considered in the book as representative examples of dynamical systems Wolfram SystemModeler in combination with Learning Management System Sakai is used as an instrument for studying features of various physical and technical phenomena and processes Each of the presented virtual labs may be considered a stand alone mini project to enable students to go through all the steps of mathematical modelling and computer simulation from the problem statement to mathematical and physical analysis of the obtained result The book is useful for teachers to organize the educational process allowing gradual monitoring of the learning process and assessment of students competencies It also allows tutors to design individual educational trajectories for students to achieve educational properties The subject of the book is an extension of activity started by the international team of authors within the InMotion project of the European programme ERASMUS   Advanced Dynamic-System Simulation Granino A. Korn,2013-02-22 A unique hands on guide to interactive modeling and simulation of engineering systems This book describes advanced cutting edge techniques for dynamic system simulation using the DESIRE modeling simulation software package It offers detailed guidance on how to implement the software providing scientists and engineers with powerful tools for creating simulation scenarios and experiments for such dynamic systems as aerospace vehicles control systems or biological systems Along with two new chapters on neural networks Advanced Dynamic System Simulation Second Edition revamps and updates all the material clarifying explanations and adding many new examples A bundled CD contains an industrial strength version of OPEN DESIRE as well as hundreds of program examples that readers can use in their own experiments The only book on the market to demonstrate model replication and Monte Carlo simulation of real world engineering systems this volume Presents a newly revised systematic procedure for difference equation modeling Covers runtime vector compilation for fast model replication on a personal computer Discusses parameter influence studies introducing very fast vectorized statistics computation Highlights Monte Carlo studies of the effects of noise and manufacturing tolerances for control system modeling Demonstrates fast compact vector models of neural networks for control engineering Features vectorized programs for fuzzy set controllers partial differential equations and agro ecological modeling Advanced Dynamic System Simulation Second Edition is a truly useful resource for researchers and design engineers in control and aerospace engineering ecology and agricultural planning It is also an excellent guide for students using DESIRE   **An Algorithm for the Computer Simulation of Large Dynamic Systems Composed of Interconnecting Subsystems** William G. Cross,1973   **Systems Modeling and Computer Simulation, Second Edition** Naim Kheir,1995-09-20 This second edition describes the fundamentals of modelling and simulation of continuous time discrete time discrete event and large scale systems Coverage new to this edition includes a chapter on non linear systems analysis and modelling complementing the treatment of of continuous time and discrete time systems and a chapter on the computer animation and visualization of dynamical systems

motion College or university bookstores may order five or more copies at a special student price available on request from Marcel Dekker Inc   *Measurements, Modelling and Simulation of Dynamic Systems* Edward Layer,Krzysztof Tomczyk,2010 This book discusses an analog to digital system intended to dynamic measurement particularly for non electrical quantities The construction and properties of measurement sensors are analyzed in detail as these represent the primary components for all measurement systems Procedures for signal noise reduction are presented based on the time window function and a digital Kalman filter Also covered in this book are the methods of modeling model development and identification procedures on the basis of measurement data The theory of maximum errors is applied in order to determine mapping errors of models in case of non standard input signals This is based on signals maximizing the chosen error functional The existence and attainability of such signals is proved and the algorithms for their determination are presented Detailed calculation methods based on dedicated numerical procedures are demonstrated which allow the integral square error as well as the absolute error to be determined The problems presented in the book are relevant to a wide range of applications where there is a requirement to determine the accuracy of indeterminate dynamic signals such as occurs in the fields of engineering medicine biology physics etc This book will interest researchers scientists engineers and graduate students in many disciplines who make use of measurements modelling and computer simulation

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