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Data-Driven Modeling & Scientific Computation About This Textbook and Courses This webpage is designed as the primary source of lectures, notes, codes and data for the textbook by J. N. Kutz on Data-Driven Modeling and Scientific Computation. The book has three parts which form the basis of three courses at the University of Washington.

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Data-driven modelling is the area of hydroinformatics undergoing fast development. This chapter reviews the main concepts and approaches of data-driven modelling, which is based on computational intelligence and machine-learning methods. A brief overview of the main methods – neural networks, fuzzy

rule-based systems and genetic algorithms, and their combination via committee approaches – is provided along with hydrological examples and references to the rest of the book.

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Combining scientific computing methods and algorithms with modern data analysis techniques, including basic applications of compressive sensing and machine learning, this book develops techniques that allow for the integration of the dynamics of complex systems and big data. MATLAB is used throughout for mathematical solution strategies.

The burgeoning field of data analysis is expanding at an incredible pace due to the proliferation of data collection in almost every area of science. The enormous data sets now routinely encountered in the sciences provide an incentive to develop mathematical techniques and computational algorithms that help synthesize, interpret and give meaning to the data in the context of its scientific setting. A specific aim of this book is to integrate standard scientific computing methods with data analysis. By doing so, it brings together, in a self-consistent fashion, the key ideas from: · statistics, · time-frequency analysis, and · low-dimensional reductions The blend of these ideas provides meaningful insight into the data sets one is faced with in every scientific subject today, including those generated from complex dynamical systems. This is a particularly exciting field and much of the final part of the book is driven by intuitive examples from it, showing how the three areas can be used in combination to give critical insight into the fundamental workings of various problems. Data-Driven Modeling and Scientific Computation is a survey of practical numerical solution techniques for ordinary and partial differential equations as well as algorithms for data manipulation and analysis. Emphasis is on the implementation of numerical schemes to practical problems in the engineering, biological and physical sciences. An accessible introductory-to-advanced text, this book fully integrates MATLAB and its versatile and high-level programming

functionality, while bringing together computational and data skills for both undergraduate and graduate students in scientific computing.

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Data-driven discovery is revolutionizing the modeling, prediction, and control of complex systems. This textbook brings together machine learning, engineering mathematics, and mathematical physics to integrate modeling and control of dynamical systems with modern methods in data science. It highlights many of the recent advances in scientific computing that enable data-driven methods to be applied to a diverse range of complex systems, such as turbulence, the brain, climate, epidemiology, finance, robotics, and autonomy. Aimed at advanced undergraduate and beginning graduate students in the engineering and physical sciences, the text presents a range of topics and methods from introductory to state of the art.

Data-driven dynamical systems is a burgeoning field?it connects how measurements of nonlinear dynamical systems and/or complex systems can be used with well-established methods in dynamical systems theory. This is a critically important new direction because the governing equations of many problems under consideration by practitioners in various scientific fields are not typically known. Thus, using data alone to help derive, in an optimal sense, the best dynamical system representation of a given application allows for important new insights. The recently developed dynamic mode decomposition (DMD) is an innovative tool for integrating data with dynamical systems theory. The DMD has deep connections with traditional dynamical systems theory and many recent innovations in compressed sensing and machine learning. Dynamic Mode Decomposition: Data-Driven Modeling of Complex Systems, the first book to address the DMD algorithm, presents a pedagogical and comprehensive approach to all aspects of DMD currently developed or under development; blends theoretical development, example codes, and applications to showcase the theory and its many innovations and uses; highlights the numerous innovations around the DMD algorithm and demonstrates its efficacy using example problems from engineering and the physical and biological sciences; and provides extensive MATLAB code, data for intuitive examples of key methods, and graphical presentations.

Describes computational methods for parametric and nonparametric modeling of stochastic dynamics. Aimed at graduate students, and suitable for self-study.

Modeling with Data fully explains how to execute computationally intensive analyses on very large data sets, showing readers how to determine the best methods for solving a variety of different problems, how to create and debug statistical models, and how to run an analysis and evaluate the results. Ben Klemens introduces a set of open and unlimited tools, and uses them to demonstrate data management, analysis, and simulation techniques essential for dealing with large data sets and computationally intensive procedures. He then demonstrates how to easily apply these tools to the many threads of statistical technique, including classical, Bayesian, maximum likelihood, and Monte Carlo methods. Klemens's accessible survey describes these models in a unified and nontraditional manner, providing alternative ways of looking at statistical concepts that often befuddle students. The book includes nearly one hundred sample programs of all kinds. Links to these programs will be available on this page at a later date. Modeling with Data will interest anyone looking for a comprehensive guide to these powerful statistical tools, including researchers and graduate students in the social sciences, biology, engineering, economics, and applied mathematics.

Trains researchers and graduate students in state-of-the-art statistical and machine learning methods to build models with real-world data.

The book of nature is written in the language of mathematics -- Galileo Galilei How is it possible to predict weather patterns for tomorrow, with access solely to today's weather data? And how is it possible to predict the aerodynamic behavior of an aircraft that has yet to be built? The answer is computer simulations based on mathematical models – sets of equations – that describe the underlying physical properties. However, these equations are usually much too complicated to solve, either by the smartest mathematician or the largest supercomputer. This problem is overcome by constructing an approximation: a numerical model with a simpler structure can be translated into a program that tells the computer how to carry out the simulation. This book conveys the fundamentals of mathematical models, numerical methods and algorithms. Opening with a tutorial on mathematical models and analysis, it proceeds to introduce the most important classes of numerical methods, with finite element, finite difference and spectral methods as central tools. The concluding section describes applications in physics and engineering, including wave propagation, heat conduction and fluid dynamics. Also covered are the principles of computers and programming, including MATLAB®.

Computational science is an exciting new field at the intersection of the sciences, computer science, and mathematics because much scientific investigation now involves computing as well as theory and experiment. This textbook provides students with a versatile and accessible introduction to the subject. It assumes only a background in high school algebra, enables instructors to follow tailored pathways through the material, and is the only textbook of its kind designed specifically for an introductory course in the computational science and engineering curriculum. While the text itself is generic, an accompanying website offers tutorials and files in a variety of software packages. This fully updated and expanded edition features two new chapters on agent-based simulations and modeling with matrices, ten new project modules, and an additional module on diffusion. Besides increased treatment of high-performance computing and its applications, the book also includes additional quick review questions with answers, exercises, and individual and team projects. The only introductory textbook of its kind—now fully updated and expanded Features two new chapters on agent-based simulations and modeling with matrices Increased coverage of high-performance computing and its applications Includes additional modules, review questions, exercises, and projects An online instructor's manual with exercise answers, selected project solutions, and a test bank and solutions (available only to professors) An online illustration package is available to professors

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