CHEM-E7190/2024: Exercise 11 Part 2/2 – Luenberger observer [EXTRA]
- Solutions

1. Design a Luenberger observer for the following state-space system. Implement the code and simulate the system in Matlab.

$$x(k+1) = \begin{bmatrix} 1.8097 & -0.8187 \\ 1 & 0 \end{bmatrix} x(k) + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u(k)$$

$$y(k) = [0.1810 \quad -0.1810] x(k) + [0] u(k)$$

Hint: First, check the observability of the system by computing the observability matrix. Then, select desired observer poles and use pole placement to compute the observer gain matrix L.

2. The dynamic equations of the stirred tank system in state-space form are the following:

$$\dot{x}(t) = \begin{bmatrix} -0.5 & 0 \\ 0 & -1 \end{bmatrix} x(t) + \begin{bmatrix} 1 & 0 & 0 \\ -0.1 & 1 & 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} x(t) + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} u(t)$$

Design a Luenberger observer for the system. Implement the code and simulate the system in Matlab.

Hint: Since all states are measured (as indicated by the identity matrix in C), consider modifying the problem by assuming one state is not measured. Then, compute the observability matrix and design the observer accordingly.

3. Calculate the observer gains for the following system when the desired characteristic equation is $(\lambda + 9)(\lambda + 10)$

$$\dot{x}(t) = \begin{bmatrix} -1 & 1 \\ 2 & -4 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

$$y(t) = [1 \quad 0] x(t)$$

Hint: Verify observability by constructing the observability matrix. Then, set up the characteristic equation of $(A - LC)$ and equate it to the desired characteristic equation to solve for the observer gains $L = \begin{bmatrix} l_1 \\ l_2 \end{bmatrix}$.

Solution

Observability

$$CA = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} -1 & 1 \\ 2 & -4 \end{bmatrix} = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

$$\mathcal{O} = \begin{bmatrix} C \\ CA \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix} \quad \text{rank}(\mathcal{O}) = 2 = N_x$$

Characteristic equation

$$A - LC = \begin{bmatrix} -1 & 1 \\ 2 & -4 \end{bmatrix} - \begin{bmatrix} l_1 \\ l_2 \end{bmatrix} \begin{bmatrix} 1 & 0 \end{bmatrix} = \begin{bmatrix} -1-l_1 & 1 \\ 2-l_2 & -4 \end{bmatrix}$$

$$|\lambda I - (A - LC)| = \begin{bmatrix} \lambda+1+l_1 & -1 \\ -2+l_2 & \lambda+4 \end{bmatrix}$$

$$(\lambda+1+l_1)(\lambda+4) - (-1)(-2+l_2) = \lambda^2 + (5+l_1)\lambda + 4(1+l_1) + l_2 - 2$$

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Luenberger Chapter Solutions

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Luenberger Chapter Solutions:

Nonlinear Functional Analysis and its Applications E. Zeidler,2013-12-11 As long as a branch of knowledge offers an abundance of problems it is full of vitality David Hilbert Over the last 15 years I have given lectures on a variety of problems in nonlinear functional analysis and its applications In doing this I have recommended to my students a number of excellent monographs devoted to specialized topics but there was no complete survey type exposition of nonlinear functional analysis making available a quick survey to the wide range of readers including mathematicians natural scientists and engineers who have only an elementary knowledge of linear functional analysis I have tried to close this gap with my five part lecture notes the first three parts of which have been published in the Teubner Texte series by Teubner Verlag Leipzig 1976 1977 and 1978 The present English edition was translated from a completely rewritten manuscript which is significantly longer than the original version in the Teubner Texte series The material is organized in the following way Part I Fixed Point Theorems Part II Monotone Operators Part III Variational Methods and Optimization Parts IV jV Applications to Mathematical Physics The exposition is guided by the following considerations a What are the supporting basic ideas and what intrinsic interrelations exist between them 3 In what relation do the basic ideas stand to the known propositions of classical analysis and linear functional analysis y What typical applications are there Vll Preface viii Special emphasis is placed on motivation

Energy, Environment and Economic Transformation in China Shiyi Chen,2018-10-24 China has achieved rapid economic growth since the market oriented reform in 1978 and became the second largest economy in the world in 2010 However the growth model in China is still extensive in nature and may be characterized with high energy consumption and heavy environmental pollutions etc In fact China has successively become the largest carbon emitter since 2007 and the largest energy consumer since 2009 in the world This book endeavors to analyze whether such energy driven and environment restricted economic growth can be sustainable in China in the long run The book describes the basic situations of energy consumption and environmental pollution in China from the dimensions of industries regions and energy types It also introduces the evolution of energy and environmental policies implemented in China In particular this book makes use of the environmental activity analysis model to assess the sustainable transformation of economic model in Chinese industries and regions This model captures the negative externalities of pollutants and estimates the environmental total factor productivity accurately The possibilities of win win development and double dividend are also forecasted This book proposes new methods to measure the environmental total factor productivity evaluate the process of low carbon transformation quantify the structural bonus estimate the abating cost and forecast the win win development and so on Researchers may find these methodologies useful for measuring other pollutants and for analysis in other countries *Model-Based Fault Diagnosis Techniques* Steven X. Ding,2012-12-20 Guaranteeing a high system performance over a wide operating range is an important issue surrounding the design of automatic control systems with successively increasing complexity As a key technology in the

search for a solution advanced fault detection and identification FDI is receiving considerable attention This book introduces basic model based FDI schemes advanced analysis and design algorithms and mathematical and control theoretic tools This second edition of Model Based Fault Diagnosis Techniques contains new material on fault isolation and identification and alarm management extended and revised treatment of systematic threshold determination for systems with both deterministic unknown inputs and stochastic noises addition of the continuously stirred tank heater as a representative process industrial benchmark and enhanced discussion of residual evaluation which now deals with stochastic processes Model based Fault Diagnosis Techniques will interest academic researchers working in fault identification and diagnosis and as a text it is suitable for graduate students in a formal university based course or as a self study aid for practising engineers working with automatic control or mechatronic systems from backgrounds as diverse as chemical process and power engineering **Quantitative Fund Management** M.A.H. Dempster,Gautam Mitra,Georg Pflug,2008-12-22 The First Collection That Covers This Field at the Dynamic Strategic and One Period Tactical Levels Addressing the imbalance between research and practice Quantitative Fund Management presents leading edge theory and methods along with their application in practical problems encountered in the fund management industry A Current Snapshot of State of the Art Applications of Dynamic Stochastic Optimization Techniques to Long Term Financial Planning The first part of the book initially looks at how the quantitative techniques of the equity industry are shifting from basic Markowitz mean variance portfolio optimization to risk management and trading applications This section also explores novel aspects of lifetime individual consumption investment problems fixed mix portfolio rebalancing allocation strategies debt management for funding mortgages and national debt and guaranteed return fund construction Up to Date Overview of Tactical Financial Planning and Risk Management The second section covers nontrivial computational approaches to tactical fund management This part focuses on portfolio construction and risk management at the individual security or fund manager level over the period up to the next portfolio rebalance It discusses non Gaussian returns new risk return tradeoffs and the robustness of benchmarks and portfolio decisions The Future Use of Quantitative Techniques in Fund Management With contributions from well known academics and practitioners this volume will undoubtedly foster the recognition and wider acceptance of stochastic optimization techniques in financial practice **Local Stability and Ultimate Boundedness in the Control of Robot Manipulators** Marco A. Arteaga,Alejandro Gutiérrez-Giles,Javier Pliego-Jiménez,2021-11-08 This book offers a unique compendium of the authors own research on the use of theoretical stability analysis showing how to take advantage of local stability design and ultimate boundedness for practical robot control It addresses researchers and postgraduate students dealing with control theory particularly with nonlinear systems Thanks to the numerous worked examples it could also be used as a textbook in postgraduate courses Asynchronous Control for Networked Systems María Guinaldo Losada,Francisco Rodríguez Rubio,Sebastián Dormido Bencomo,2015-09-08 This book sheds light on networked control

systems it describes different techniques for asynchronous control moving away from the periodic actions of classical control replacing them with state based decisions and reducing the frequency with which communication between subsystems is required The text focuses specially on event based control Split into two parts Asynchronous Control for Networked Systems begins by addressing the problems of single loop networked control systems laying out various solutions which include two alternative model based control schemes anticipatory and predictive and the use of H2 H robust control to deal with network delays and packet losses Results on self triggering and send on delta sampling are presented to reduce the need for feedback in the loop In Part II the authors present solutions for distributed estimation and control They deal first with reliable networks and then extend their results to scenarios in which delays and packet losses may occur The novel results presented in Asynchronous Control for Networked Systems are transmitted in a concise and clear style supported by simulation and experimental examples Some applications are also provided Academic researchers and graduate students investigating control theory control engineering and computer communications systems can use this monograph to learn how asynchronous control helps tackle the problems of networked systems in centralized and distributed schemes Control practitioners at work in power systems vehicle coordination and traffic networks will also find this book helpful in improving the performance of their systems   From Static to Dynamic Couplings in Consensus and Synchronization Among Identical and Non-Identical Systems Peter Wieland,2010 In a systems theoretic context the terms consensus and synchronization both describe the property that all individual systems in a group behave asymptotically identical i e output or state trajectories asymptotically converge to a common trajectory The objective of the present thesis is an improved understanding of some of the diverse coupling mechanisms leading to consensus and synchronization A starting point is the observation that classical consensus and synchronization results commonly deal with two distinct facets of the problem Consensus has regularly a strong focus on the interconnections and related constraints while synchronization typically addresses questions about complex individual dynamical systems Very few results exist that address both facets simultaneously A thorough analysis of static couplings in consensus algorithms provides explanations for this observation by unveiling limitations inherent to this type of couplings Novel dynamic coupling mechanisms are proposed to overcome these limitations These methods essentially rely on an internal model principle for consensus and synchronization derived in the thesis This principle provides necessary conditions for consensus and synchronization in groups of non identical systems and it establishes a link to the output regulation problem The fresh point of view revealed by this link eventually leads to a new hierarchical mechanism for consensus and synchronization among complex non identical systems with weak assumptions on the interconnections Applications include synchronization of linear systems and phase synchronization of nonlinear oscillators   Numerical Solution of Systems of Simultaneous Polynomial Equations Stanford University. Systems Optimization Laboratory,A. N. Rosenberg,1983   **Journal of Applied Mechanics** ,1975 Publishes original research in all branches of mechanics

including aerodynamics aeroelasticity boundary layers computational mechanics constitutive modeling of materials dynamics elasticity flow and fracture heat transfer hydraulics impact internal flow mechanical properties of materials micromechanics plasticity stress analysis structures thermodynamics turbulence vibration and wave propagation **Introduction to Modern Economic Growth** Daron Acemoglu,2008-12-15 From Nobel Prize winning economist Daron Acemoglu an incisive introduction to economic growth Introduction to Modern Economic Growth is a groundbreaking text from one of today s leading economists Daron Acemoglu gives graduate students not only the tools to analyze growth and related macroeconomic problems but also the broad perspective needed to apply those tools to the big picture questions of growth and divergence And he introduces the economic and mathematical foundations of modern growth theory and macroeconomics in a rigorous but easy to follow manner After covering the necessary background on dynamic general equilibrium and dynamic optimization the book presents the basic workhorse models of growth and takes students to the frontier areas of growth theory including models of human capital endogenous technological change technology transfer international trade economic development and political economy The book integrates these theories with data and shows how theoretical approaches can lead to better perspectives on the fundamental causes of economic growth and the wealth of nations Innovative and authoritative this book is likely to shape how economic growth is taught and learned for years to come Introduces all the foundations for understanding economic growth and dynamic macroeconomic analysis Focuses on the big picture questions of economic growth Provides mathematical foundations Presents dynamic general equilibrium Covers models such as basic Solow neoclassical growth and overlapping generations as well as models of endogenous technology and international linkages Addresses frontier research areas such as international linkages international trade political economy and economic development and structural change An accompanying Student Solutions Manual containing the answers to selected exercises is available 978 0 691 14163 3 24 95 See https press princeton edu titles 8970 html For Professors only To access a complete solutions manual online email us at acemoglusolutions press princeton edu **Sourcebook Of Control Systems Engineering** L. C. Westphal,1995-03-31 This book joins the multitude of Control Systems books now available but is neither a textbook nor a monograph Rather it may be described as a resource book or survey of the elements essentials of feedback control systems The material included is a result of my development over a period of several years of summaries written to supplement a number of standard textbooks for undergraduate and early post graduate courses Those notes plus more work than I care right now to contemplate are intended to be helpful both to students and to professional engineers Too often standard textbooks seem to overlook some of the engineering realities of roughly how much things cost or how big of hardware for computer programs for simple algorithms are sensing and actuation of special systems such as PLCs and PID controllers of the engineering of real systems from coverage of SISO theories and of the special characteristics of computers their programming and their potential interactions into systems In particular students with specializations other than control

systems are not being exposed to the breadth of the considerations needed in control systems engineering perhaps because it is assumed that they are always to be part of a multicourse sequence taken by specialists The lectures given to introduce at least some of these aspects were more effective when supported by written material hence the need for my notes which preceded this book   Deterministic L2/H2 Optimization of Linear Dynamical Systems Nader Safari-Shad,1992

Proceedings of the 2005 Design, Analysis, and Simulation of Distributed Systems Symposium Dietmar Tutsch,2005

Generation of Feasible Descent Directions in Continuous Time Linear Programming Stanford University. Systems Optimization Laboratory,Kurt Martin Anstreicher,1983   **Introduction to Dynamic Systems** David G. Luenberger,1979-05-28 Difference and differential equations Linear algebra Linear state equations Linear systems with constant coefficients Positive systems Markov chains Concepts of control Analysis of nonlinear systems Some important dynamic systems Optimal control   **Microeconomic Theory** David G. Luenberger,1995   **Modal Control: Theory and Applications** Brian Porter,1972   **Spatial Time Series** Robert John Bennett,1979   **Mathematical Programming and Games** Edward L. Kaplan,1982-04-16   Dynamic Compensation Models Yechong Chen,2000

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