

# MAE 270B Linear Optimal Control

Lecture: MW 12:00-12:50

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Class Homepage:

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## Course Description:

Performance analysis of linear state space systems, Gramians and Lyapunov equations,  $H_2$  performance and quadratic cost, reachable set and energy-to-peak gain, solutions to  $H_2$  optimal control problems, linear quadratic regulator (LQR), Kalman filter, dynamic output feedback design with the separation principle, Hamiltonian systems and Riccati equations, robustness issues, implications of controllability, stabilizability, observability, and detectability, full parameterization and the projection theorem.

# Linear Optimal Control

**Alexander J. Zaslavski**



## **Linear Optimal Control:**

*Optimal Control* Brian D. O. Anderson, John B. Moore, 2007-02-27 Numerous examples highlight this treatment of the use of linear quadratic Gaussian methods for control system design It explores linear optimal control theory from an engineering viewpoint with illustrations of practical applications Key topics include loop recovery techniques frequency shaping and controller reduction Numerous examples and complete solutions 1990 edition *Linear Optimal Control Systems* Huibert Kwakernaak, Raphael Sivan, 1972-11-10 This book attempts to reconcile modern linear control theory with classical control theory One of the major concerns of this text is to present design methods employing modern techniques for obtaining control systems that stand up to the requirements that have been so well developed in the classical expositions of control theory Therefore among other things an entire chapter is devoted to a description of the analysis of control systems mostly following the classical lines of thought In the later chapters of the book in which modern synthesis methods are developed the chapter on analysis is recurrently referred to Furthermore special attention is paid to subjects that are standard in classical control theory but are frequently overlooked in modern treatments such as nonzero set point control systems tracking systems and control systems that have to cope with constant disturbances Also heavy emphasis is placed upon the stochastic nature of control problems because the stochastic aspects are so essential Preface *Linear Optimal Control* Brian D. O. Anderson, John Barratt Moore, 1971 **Optimal Control and Estimation** Robert F. Stengel, 1994-09-20 An excellent introduction to optimal control and estimation theory and its relationship with LQG design invaluable as a reference for those already familiar with the subject Automatica This highly regarded graduate level text provides a comprehensive introduction to optimal control theory for stochastic systems emphasizing application of its basic concepts to real problems The first two chapters introduce optimal control and review the mathematics of control and estimation Chapter 3 addresses optimal control of systems that may be nonlinear and time varying but whose inputs and parameters are known without error Chapter 4 of the book presents methods for estimating the dynamic states of a system that is driven by uncertain forces and is observed with random measurement error Chapter 5 discusses the general problem of stochastic optimal control and the concluding chapter covers linear time invariant systems Robert F Stengel is Professor of Mechanical and Aerospace Engineering at Princeton University where he directs the Topical Program on Robotics and Intelligent Systems and the Laboratory for Control and Automation He was a principal designer of the Project Apollo Lunar Module control system An excellent teaching book with many examples and worked problems which would be ideal for self study or for use in the classroom The book also has a practical orientation and would be of considerable use to people applying these techniques in practice Short Book Reviews Publication of the International Statistical Institute An excellent book which guides the reader through most of the important concepts and techniques A useful book for students and their teachers and for those practicing engineers who require a comprehensive reference to the subject Library Reviews The Royal Aeronautical Society Optimal

Control Brian D. O. Anderson, John Barratt Moore, 1990      *Linear Control Theory* Shankar P. Bhattacharyya, Aniruddha Datta, Lee H. Keel, 2018-10-03 Successfully classroom tested at the graduate level Linear Control Theory Structure Robustness and Optimization covers three major areas of control engineering PID control robust control and optimal control It provides balanced coverage of elegant mathematical theory and useful engineering oriented results The first part of the book develops results relating to the design of PID and first order controllers for continuous and discrete time linear systems with possible delays The second section deals with the robust stability and performance of systems under parametric and unstructured uncertainty This section describes several elegant and sharp results such as Kharitonov's theorem and its extensions the edge theorem and the mapping theorem Focusing on the optimal control of linear systems the third part discusses the standard theories of the linear quadratic regulator H-infinity and L1 optimal control and associated results Written by recognized leaders in the field this book explains how control theory can be applied to the design of real world systems It shows that the techniques of three term controllers along with the results on robust and optimal control are invaluable to developing and solving research problems in many areas of engineering      **Linear Optimal Control Theory and a Traditional Process Control Problem** J. F. Lambert, 1980      Optimal Control Methods for Linear Discrete-Time Economic Systems Y. Murata, 2012-12-06 As our title reveals we focus on optimal control methods and applications relevant to linear dynamic economic systems in discrete time variables We deal only with discrete cases simply because economic data are available in discrete forms hence realistic economic policies should be established in discrete time structures Though many books have been written on optimal control in engineering we see few on discrete type optimal control More over since economic models take slightly different forms than do engineering ones we need a comprehensive self contained treatment of linear optimal control applicable to discrete time economic systems The present work is intended to fill this need from the standpoint of contemporary macroeconomic stabilization The work is organized as follows In Chapter 1 we demonstrate instrument instability in an economic stabilization problem and thereby establish the motivation for our departure into the optimal control world Chapter 2 provides fundamental concepts and propositions for controlling linear deterministic discrete time systems together with some economic applications and numerical methods Our optimal control rules are in the form of feedback from known state variables of the preceding period When state variables are not observable or are accessible only with observation errors we must obtain appropriate proxies for these variables which are called observers in deterministic cases or filters in stochastic circumstances In Chapters 3 and 4 respectively Luenberger observers and Kalman filters are discussed developed and applied in various directions Noticing that a separation principle lies between observer or filter and controller cf      Turnpike Theory of Continuous-Time Linear Optimal Control Problems Alexander J. Zaslavski, 2015-07-01 Individual turnpike results are of great interest due to their numerous applications in engineering and in economic theory in this book the study is focused on new results of turnpike phenomenon in linear

optimal control problems The book is intended for engineers as well as for mathematicians interested in the calculus of variations optimal control and in applied functional analysis Two large classes of problems are studied in more depth The first class studied in Chapter 2 consists of linear control problems with periodic nonsmooth convex integrands Chapters 3 5 consist of linear control problems with autonomous convex smooth integrands Chapter 6 discusses a turnpike property for dynamic zero sum games with linear constraints Chapter 7 examines genericity results In Chapter 8 the description of structure of variational problems with extended valued integrands is obtained Chapter 9 ends the exposition with a study of turnpike phenomenon for dynamic games with extended value integrands

**Stochastic Linear-Quadratic Optimal Control Theory: Open-Loop and Closed-Loop Solutions** Jingrui Sun, Jiongmin Yong, 2020-06-29 This book gathers the most essential results including recent ones on linear quadratic optimal control problems which represent an important aspect of stochastic control It presents the results in the context of finite and infinite horizon problems and discusses a number of new and interesting issues Further it precisely identifies for the first time the interconnections between three well known relevant issues the existence of optimal controls solvability of the optimality system and solvability of the associated Riccati equation Although the content is largely self contained readers should have a basic grasp of linear algebra functional analysis and stochastic ordinary differential equations The book is mainly intended for senior undergraduate and graduate students majoring in applied mathematics who are interested in stochastic control theory However it will also appeal to researchers in other related areas such as engineering management finance economics and the social sciences

**Applied Linear Optimal Control Paperback with CD-ROM** Arthur E. Bryson, 2002-08-29 CD ROM contains MATLAB codes of the OPTEST toolbox Code for examples figures and selected problems in text

**On Linear Optimal Control Problems with Multiple Quadratic Criteria** Ronald J. Stern, Adi Ben-Israel, 1972

**Linear Optimal Control** Jeffrey B. Burl, 1999 Preface List of symbols Introduction Analysis of control systems Multivariable systems Vector random processes Performance

Robustness The linear quadratic regulator The Kalman filter Linear quadratic Gaussian control Control Full information control estimation H infinity symbol output feedback Controller order reduction Appendix Mathematical notes

*Analytical and Computational Aspects of the Linear Optimal Control Problem* O. H. D. Walter, Control Systems Centre, 1971

**Optimal Control** Zoran Gajic, Myo-Taeg Lim, Dobrila Skataric, Wu-Chung Su, Vojislav Kecman, 2018-10-03 Unique in scope Optimal Control Weakly Coupled Systems and Applications provides complete coverage of modern linear bilinear and nonlinear

optimal control algorithms for both continuous time and discrete time weakly coupled systems using deterministic as well as stochastic formulations This book presents numerous applications to real world systems from various industries including

aerospace and discusses the design of subsystem level optimal filters Organized into independent chapters for easy access to the material this text also contains several case studies examples exercises computer assignments and formulations of

research problems to help instructors and students

*Linear Optimal Control of Bilinear Systems* Aganović Zijad, 1995

**Linear Optimal Control [by] Brian D.O. Anderson [and] John B. Moore** Brian D. O. Anderson, 1971      Constrained Optimal Control of Linear and Hybrid Systems Francesco Borrelli, 2003-09-04 Many practical control problems are dominated by characteristics such as state input and operational constraints alternations between different operating regimes and the interaction of continuous time and discrete event systems At present no methodology is available to design controllers in a systematic manner for such systems This book introduces a new design theory for controllers for such constrained and switching dynamical systems and leads to algorithms that systematically solve control synthesis problems The first part is a self contained introduction to multiparametric programming which is the main technique used to study and compute state feedback optimal control laws The book s main objective is to derive properties of the state feedback solution as well as to obtain algorithms to compute it efficiently The focus is on constrained linear systems and constrained linear hybrid systems The applicability of the theory is demonstrated through two experimental case studies a mechanical laboratory process and a traction control system developed jointly with the Ford Motor Company in Michigan      *Study of Solutions to a Family of Linear Optimal Control Problems Depending on a Parameter* Olga Ivanovna Kostjukova, 1997      *Concepts of General System Theory in the Linear Optimal Control Problem* Harold Nicholson, 1970

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