

## Chapter 6

### Mean-Variance Portfolio Theory

1. (Shorting with margin) The money invested is  $X_0$ . The money received at the end of a year is  $X_0 - X_1 + X_0$ . Hence,

$$R = \frac{2X_0 - X_1}{X_0}$$

2. (Dice product) Let  $a$  and  $b$  be the outcomes of two dice rolls. Then  $Z = ab$ . By independence, we know

$$\begin{aligned} E[ab] &= E[a]E[b] \\ \text{and } \text{var}[Z] &= E[a^2]E[b^2] - (E[a]E[b])^2 \\ &\approx 79.97 \end{aligned}$$

3. (Two correlated assets) For solution method, see solution to problem called Two stocks (below).

(a)  $\alpha$  equals  $19/23$ .

(b) The minimum standard deviation is approximately 13.7%.

(c) The expected return of this portfolio is approximately 11.4%.

4. (Two stocks) Let  $\alpha, \beta$  equal the percent of investment in stock 1 and stock 2, respectively. The problem is

$$\min \alpha^2 \sigma_1^2 + \beta^2 \sigma_2^2 + 2\alpha\beta\sigma_{12}$$

$$\text{subject to } \alpha + \beta = 1.$$

Setting up the Lagrangian,  $L$ , we have:

$$L = \alpha^2 \sigma_1^2 + \beta^2 \sigma_2^2 + 2\alpha\beta\sigma_{12} - \lambda(\alpha + \beta - 1)$$

The first order necessary conditions are:

$$0 = \frac{\partial L}{\partial \alpha} = 2\alpha\sigma_1^2 + 2\beta\sigma_{12} - \lambda$$

# Luenberger Chapter

**Robin C. Sickles, Valentin Zelenyuk**



## **Luenberger Chapter :**

**Observers in Control Systems** George Ellis, 2002-10-16 Observers are digital algorithms that combine sensor outputs with knowledge of the system to provide results superior to traditional structures which rely wholly on sensors. Observers have been used in selected industries for years but most books explain them with complex mathematics. *Observers in Control Systems* uses intuitive discussion, software experiments, and supporting analysis to explain the advantages and disadvantages of observers. If you are working in controls and want to improve your control systems, observers could be the technology you need, and this book will give you a clear, thorough explanation of how they work and how to use them. Control systems and devices have become the most essential part of nearly all mechanical systems, machines, devices, and manufacturing systems throughout the world. Increasingly, the efficiency of production, the reliability of output, and increased energy savings are a direct result of the quality and deployment of the control system. A modern and essential tool within the engineer's kit is the Observer, which helps improve the performance and reduce the cost of these systems. George Ellis is the author of the highly successful *Control System Design Guide*, Second Edition. Unlike most controls books, which are written by control theorists and academics, Ellis is a leading engineer, designer, author, and lecturer working in industry directly with the users of industrial motion control systems. *Observers in Control Systems* is written for all professional engineers and is designed to be utilized without an in-depth background in control theory. This is a real-world book which will demonstrate how observers work and how they can improve your control system. It also shows how observers operate when conditions are not ideal and teaches the reader how to quickly tune an observer in a working system. Software Available online: A free, updated and enhanced version of the author's popular Visual ModelQ allows the reader to practice the concepts with Visual ModelQ models on a PC. Based on a virtual laboratory, all key topics are demonstrated with more than twenty control system models. The models are written in Visual ModelQ and are available on the Internet to every reader with a PC. Teaches observers and Kalman filters from an intuitive perspective. Explains how to reduce control system susceptibility to noise. Shows how to design an adaptive controller based on estimating parameter variation using observers. Shows how to improve a control system's ability to reject disturbances. Key topics are demonstrated with PC-based models of control systems. The models are written in both MatLab and ModelQ; models are available free of charge.

*Investment Theory and Risk Management, + Website* Steven Peterson, 2012-05-08 A unique perspective on applied investment theory and risk management from the Senior Risk Officer of a major pension fund. *Investment Theory and Risk Management* is a practical guide to today's investment environment. The book's sophisticated quantitative methods are examined by an author who uses these methods at the Virginia Retirement System and teaches them at the Virginia Commonwealth University. In addition to showing how investment performance can be evaluated using Jensen's Alpha, Sharpe's Ratio, and DDM, he delves into four types of optimal portfolios: one that is fully invested, one with targeted returns, another with no short sales, and one with capped investment.

allocations In addition the book provides valuable insights on risk and topics such as anomalies factor models and active portfolio management Other chapters focus on private equity structured credit optimal rebalancing data problems and Monte Carlo simulation Contains investment theory and risk management spreadsheet models based on the author's own real world experience with stock bonds and alternative assets Offers a down to earth guide that can be used on a daily basis for making common financial decisions with a new level of quantitative sophistication and rigor Written by the Director of Research and Senior Risk Officer for the Virginia Retirement System and an Associate Professor at Virginia Commonwealth University's School of Business Investment Theory and Risk Management empowers both the technical and non technical reader with the essential knowledge necessary to understand and manage risks in any corporate or economic environment Handbook of Control Systems Engineering Louis C. Westphal, 2012-12-06 This book is a revision and extension of my 1995 Sourcebook of Control Systems Engineering Because of the extensions and other modifications it has been retitled Handbook of Control Systems Engineering which it is intended to be for its prime audience advanced undergraduate students beginning graduate students and practising engineers needing an understandable review of the field or recent developments which may prove useful There are several differences between this edition and the first Two new chapters on aspects of nonlinear systems have been incorporated In the first of these selected material for nonlinear systems is concentrated on four aspects showing the value of certain linear controllers arguing the suitability of algebraic linearization reviewing the semi classical methods of harmonic balance and introducing the nonlinear change of variable technique known as feedback linearization In the second chapter the topic of variable structure control often with sliding mode is introduced Another new chapter introduces discrete event systems including several approaches to their analysis The chapters on robust control and intelligent control have been extensively revised Modest revisions and extensions have also been made to other chapters often to incorporate extensions to nonlinear systems Difference Equations, Second Edition R Mickens, 1991-01-01 In recent years the study of difference equations has acquired a new significance due in large part to their use in the formulation and analysis of discrete time systems the numerical integration of differential equations by finite difference schemes and the study of deterministic chaos The second edition of Difference Equations Theory and Applications provides a thorough listing of all major theorems along with proofs The text treats the case of first order difference equations in detail using both analytical and geometrical methods Both ordinary and partial difference equations are considered along with a variety of special nonlinear forms for which exact solutions can be determined Numerous worked examples and problems allow readers to fully understand the material in the text They also give possible generalization of the theorems and application models The text's expanded coverage of application helps readers appreciate the benefits of using difference equations in the modeling and analysis of realistic problems from a broad range of fields The second edition presents analyzes and discusses a large number of applications from the mathematical biological physical and social sciences Discussions on perturbation methods and

difference equation models of differential equation models of differential equations represent contributions by the author to the research literature Reference to original literature show how the elementary models of the book can be extended to more realistic situations Difference Equations Second Edition gives readers a background in discrete mathematics that many workers in science oriented industries need as part of their general scientific knowledge With its minimal mathematical background requirements of general algebra and calculus this unique volume will be used extensively by students and professional in science and technology in areas such as applied mathematics control theory population science economics and electronic circuits especially discrete signal processing      *Uncertainty, Production, Choice, and Agency* Robert G. Chambers, John Quiggin, 2000-09-18 This book presents a justification of the state contingent approach to the economics of uncertainty      **Advances in Observer Design and Observation for Nonlinear Systems** Omar Naifar, Abdellatif Ben Makhlouf, 2022-02-01 This book discusses various methods for designing different kinds of observers such as the Luenberger observer unknown input observers discontinuous observers sliding mode observers observers for impulsive systems observers for nonlinear Takagi Sugeno fuzzy systems and observers for electrical machines A hydraulic process system and a renewable energy system are provided as examples of applications      **Convex Optimization** Stephen Boyd, Lieven Vandenbergh, 2004-03-08 Convex optimization problems arise frequently in many different fields This book provides a comprehensive introduction to the subject and shows in detail how such problems can be solved numerically with great efficiency The book begins with the basic elements of convex sets and functions and then describes various classes of convex optimization problems Duality and approximation techniques are then covered as are statistical estimation techniques Various geometrical problems are then presented and there is detailed discussion of unconstrained and constrained minimization problems and interior point methods The focus of the book is on recognizing convex optimization problems and then finding the most appropriate technique for solving them It contains many worked examples and homework exercises and will appeal to students researchers and practitioners in fields such as engineering computer science mathematics statistics finance and economics      Sourcebook Of Control Systems Engineering Louis C. Westphal, 2012-12-06 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

**Control in Bioprocessing** Pablo A. López Pérez, Ricardo Aguilar López, Ricardo Femat, 2020-03-10 Closes the gap between bioscience and mathematics based process engineering This book presents the most commonly employed approaches in the control of bioprocesses It discusses the role that control theory plays in understanding the mechanisms of cellular and metabolic processes and presents key results in various fields such as dynamic modeling dynamic properties of bioprocess models software sensors designed for the online estimation of parameters and state variables and control and supervision of bioprocesses Control in Bioengineering and Bioprocessing Modeling Estimation and the Use of Sensors is divided into three sections Part I Mathematical preliminaries and overview of the control and monitoring of bioprocess provides a general overview of the control and monitoring of bioprocesses and introduces the mathematical framework necessary for the analysis and characterization of bioprocess dynamics Part II Observability and control concepts presents the observability concepts which form the basis of design online estimation algorithms software sensor for bioprocesses and reviews controllability of these concepts including automatic feedback control systems Part III Software sensors and observer based control schemes for bioprocesses features six application cases including dynamic behavior of 3 dimensional continuous bioreactors observability analysis applied to 2D and 3D bioreactors with inhibitory and non inhibitory models and regulation of a continuously stirred bioreactor via modeling error compensation Applicable across all areas of bioprocess engineering including food and beverages biofuels and renewable energy pharmaceuticals and nutraceuticals fermentation systems product separation technologies wastewater and solid waste treatment technology and bioremediation Provides a clear explanation of the mass balance based mathematical modelling of bioprocesses and the main tools for its dynamic analysis Offers industry based applications on myco diesel for implementing quality of observability developing a virtual sensor based on the Just In Time Model to monitor biological control systems and virtual sensor design for state estimation in a photocatalytic bioreactor for hydrogen production Control in Bioengineering and Bioprocessing is intended as a foundational text for graduate level students in bioengineering as well as a reference text for researchers engineers and other practitioners interested in the field of estimation and control of bioprocesses

Difference Equations, Second Edition Ronald E. Mickens, 2022-02-17 In recent years the study of difference equations has acquired a new significance due in large part to their use in the formulation and analysis of discrete time systems the numerical integration of differential equations by finite difference schemes and the study of deterministic chaos The second edition of Difference Equations Theory and Applications provides a thorough listing of all major theorems along with proofs The text treats the case of first order

difference equations in detail using both analytical and geometrical methods Both ordinary and partial difference equations are considered along with a variety of special nonlinear forms for which exact solutions can be determined Numerous worked examples and problems allow readers to fully understand the material in the text They also give possible generalization of the theorems and application models The text s expanded coverage of application helps readers appreciate the benefits of using difference equations in the modeling and analysis of realistic problems from a broad range of fields The second edition presents analyzes and discusses a large number of applications from the mathematical biological physical and social sciences Discussions on perturbation methods and difference equation models of differential equation models of differential equations represent contributions by the author to the research literature Reference to original literature show how the elementary models of the book can be extended to more realistic situations Difference Equations Second Edition gives readers a background in discrete mathematics that many workers in science oriented industries need as part of their general scientific knowledge With its minimal mathematical background requirements of general algebra and calculus this unique volume will be used extensively by students and professional in science and technology in areas such as applied mathematics control theory population science economics and electronic circuits especially discrete signal processing

### **Control System**

**Design Guide** George Ellis, 2012-05-15 This title will help engineers to apply control theory to practical systems using their PC It provides an intuitive approach to controls avoiding unnecessary math and emphasising key concepts with control system models

Deterministic Observation Theory and Applications Jean-Paul Gauthier, Ivan Kupka, 2001-10-08 This 2001 book presents a general theory as well as a constructive methodology to solve observation problems that is reconstructing the full information about a dynamical process on the basis of partial observed data A general methodology to control processes on the basis of the observations is also developed Illustrative but also practical applications in the chemical and petroleum industries are shown This book is intended for use by scientists in the areas of automatic control mathematics chemical engineering and physics

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

**Zonotopes** Vu Tuan Hieu Le, Cristina Stoica, Teodoro Alamo, Eduardo F. Camacho, Didier Dumur, 2013-12-04 This title focuses on two significant problems in the field of automatic control in particular state estimation and robust Model Predictive Control under input and state constraints bounded disturbances and measurement noises The authors build upon previous results concerning zonotopic set membership state estimation and output feedback tube based Model Predictive Control Various existing zonotopic set membership estimation methods are investigated and their advantages and drawbacks are discussed making this book suitable both for researchers working in automatic control and industrial partners interested in applying the proposed techniques to real systems The authors proceed to focus on a new method based on the minimization of the P radius of a zonotope in order to obtain a good trade off between the complexity and the accuracy of the estimation They propose a P radius based set membership estimation method to compute a zonotope containing the real states of a system which are consistent with the disturbances and measurement noise The problem of output feedback control using a zonotopic set membership estimation is also explored Among the approaches from existing literature on the subject the implementation of robust predictive techniques based on tubes of trajectories is developed

Contents 1 Uncertainty Representation Based on Set Theory 2 Several Approaches on Zonotopic Guaranteed Set Membership Estimation 3 Zonotopic Guaranteed State Estimation Based on P Radius Minimization 4 Tube Model Predictive Control Based on Zonotopic Set Membership Estimation

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**Handbook of Operations Analytics Using Data Envelopment Analysis** Shih-Nan Hwang, Hsuan-Shih Lee, Joe Zhu, 2016-07-01 This handbook focuses on Data Envelopment Analysis DEA applications in operations analytics which are fundamental tools and techniques for improving operation functions and attaining long term competitiveness In fact the handbook demonstrates that DEA can be viewed as Data Envelopment Analytics Chapters include a review of cross efficiency evaluation a case study on measuring the environmental performance of OECD countries how to select a set of performance metrics in DEA with an application to American banks a relational network model to take the operations of individual periods



into account in measuring efficiencies how the efficient frontier methods DEA and stochastic frontier analysis SFA can be used synergistically and how to integrate DEA and multidimensional scaling In other chapters authors construct a dynamic three stage network DEA model a bootstrapping based methodology to evaluate returns to scale and convexity assumptions in DEA hybridizing DEA and cooperative games using DEA to represent the production technology and directional distance functions to measure bank performance an input specific Luenberger energy and environmental productivity indicator and the issue of reference set by differentiating between the uniquely found reference set and the unary and maximal types of the reference set Finally additional chapters evaluate and compare the technological advancement observed in different hybrid electric vehicles HEV market segments over the past 15 years radial measurement of efficiency for the production process possessing multi components under different production technologies issues around the use of accounting information in DEA how to use DEA environmental assessment to establish corporate sustainability a summary of research efforts on DEA environmental assessment applied to energy in the last 30 years and an overview of DEA and how it can be utilized alone and with other techniques to investigate corporate environmental sustainability questions

**Mathematics for Dynamic Modeling** Edward Beltrami, 1998 This new edition of Mathematics for Dynamic Modeling updates a widely used and highly respected textbook The text is appropriate for upper level undergraduate and graduate level courses in modeling dynamical systems differential equations and linear multivariable systems offered in a variety of departments including mathematics engineering computer science and economics The text features many different realistic applications from a wide variety of disciplines The book covers important tools such as linearization feedback concepts the use of Liapunov functions and optimal control This new edition is a valuable tool for understanding and teaching a rapidly growing field Practitioners and researchers may also find this book of interest Contains a new chapter on stability of dynamic models Covers many realistic applications from a wide variety of fields in an accessible manner Provides a broad introduction to the full scope of dynamical systems Incorporates new developments such as new models for chemical reactions and autocatalysis Integrates MATLAB throughout the text in both examples and illustrations Includes a new introduction to nonlinear differential equations

**Robust Control** Farhad Assadian, Kevin R. Mallon, 2022-01-28 Robust Control Robust Control Youla Parameterization Approach Discover efficient methods for designing robust control systems In Robust Control Youla Parameterization Approach accomplished engineers Dr Farhad Assadian and Kevin R Mallon deliver an insightful treatment of robust control system design that does not require a theoretical background in controls The authors connect classical control theory to modern control concepts using the Youla method and offer practical examples from the automotive industry for designing control systems with the Youla method The book demonstrates that feedback control can be elegantly designed in the frequency domain using the Youla parameterization approach It offers deep insights into the many practical applications from utilizing this technique in both Single Input Single Output SISO and Multiple Input Multiple Output MIMO design

Finally the book provides an estimation technique using Youla parameterization and controller output observer for the first time Robust Control offers readers A thorough introduction to a review of the Laplace Transform including singularity functions and transfer functions Comprehensive explorations of the response of linear time invariant and dynamic systems as well as feedback principles and feedback design for SISO Practical discussions of norms and feedback systems feedback design by the optimization of closed loop norms and estimation design for SISO using the parameterization approach In depth examinations of MIMO control and multivariable transfer function properties Perfect for industrial researchers and engineers working with control systems Robust Control Youla Parameterization Approach is also an indispensable resource for graduate students in mechanical aerospace electrical and chemical engineering

**Foundations of Mathematical Economics** Michael Carter, 2001-10-26 This book provides a comprehensive introduction to the mathematical foundations of economics from basic set theory to fixed point theorems and constrained optimization Rather than simply offer a collection of problem solving techniques the book emphasizes the unifying mathematical principles that underlie economics Features include an extended presentation of separation theorems and their applications an account of constraint qualification in constrained optimization and an introduction to monotone comparative statics These topics are developed by way of more than 800 exercises The book is designed to be used as a graduate text a resource for self study and a reference for the professional economist

Applied Dynamic Programming for Optimization of Dynamical Systems Rush D. Robinett III, David G. Wilson, G. Richard Eisler, John E. Hurtado, 2005-01-01 Based on the results of over 10 years of research and development by the authors this book presents a broad cross section of dynamic programming DP techniques applied to the optimization of dynamical systems The main goal of the research effort was to develop a robust path planning trajectory optimization tool that did not require an initial guess The goal was partially met with a combination of DP and homotopy algorithms DP algorithms are presented here with a theoretical development and their successful application to variety of practical engineering problems is emphasized

Measurement of Productivity and Efficiency Robin C. Sickles, Valentin Zelenyuk, 2019-03-28 Provides a comprehensive approach to productivity and efficiency analysis using economic and econometric theory

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