

Problem 1. (Transformation to controllable canonical form). Consider the following third-order SISO LTI system

$$\dot{x} = Ax + Bu, \quad x \in \mathbb{R}^3, u \in \mathbb{R}^1 \quad (\text{AB-CLTI})$$

Assume that the characteristic polynomial of A is given by

$$\det(sI - A) = s^3 + \alpha_1 s^2 + \alpha_2 s + \alpha_3$$

and consider the 3×3 matrix

$$T := C \begin{bmatrix} 1 & \alpha_1 & \alpha_2 \\ 0 & 1 & \alpha_1 \\ 0 & 0 & 1 \end{bmatrix}$$

where C is the system's controllability matrix.

(a) Show that the following equality holds:

$$B = T \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

(b) Show that the following equality holds:

$$AT = T \begin{bmatrix} -\alpha_1 & -\alpha_2 & -\alpha_3 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

(c) Show that if the system (AB-CLTI) is controllable, then T is a nonsingular matrix.

(d) Combining parts (a)–(c), you showed that, if the system (AB-CLTI) is controllable, then the matrix T given above can be viewed as a similarity transformation that transforms the system into the controllable canonical form

$$T^{-1}AT = \begin{bmatrix} -\alpha_1 & -\alpha_2 & -\alpha_3 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}, \quad T^{-1}B = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}.$$

Use this to find the similarity transformation that transforms the following pair into the controllable canonical form

$$A := \begin{bmatrix} 6 & 4 & 1 \\ -5 & -4 & 0 \\ -4 & -3 & -1 \end{bmatrix}, \quad B := \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix}.$$

Linear Systems Theory Hespanha Solutions

**Jean Auriol,Joachim
Deutscher,Guilherme Mazanti,Giorgio
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Saito,2013-12-23 Theoretical tools and insights from discrete mathematics theoretical computer science and topology now play essential roles in our understanding of vital biomolecular processes The related methods are now employed in various fields of mathematical biology as instruments to zoom in on processes at a molecular level This book contains expository chapters on how contemporary models from discrete mathematics in domains such as algebra combinatorics and graph and knot theories can provide perspective on biomolecular problems ranging from data analysis molecular and gene arrangements and structures and knotted DNA embeddings via spatial graph models to the dynamics and kinetics of molecular interactions The contributing authors are among the leading scientists in this field and the book is a reference for researchers in mathematics and theoretical computer science who are engaged with modeling molecular and biological phenomena using discrete methods It may also serve as a guide and supplement for graduate courses in mathematical biology or bioinformatics introducing nontraditional aspects of mathematical biology Hybrid Systems with Constraints

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Hybrid Systems: Computation and Control Joao Hespanha, 2006-03-20 This book constitutes the refereed proceedings of the 9th International Workshop on Hybrid Systems Computation and Control HSCC 2006 held in Santa Barbara CA USA in March 2006 The 39 revised full papers presented together with the abstracts of 3 invited talks were carefully reviewed and selected from 79 submissions Among the topics addressed are tools for analysis and verification control and optimization modeling engineering applications and emerging directions in programming language support and implementation The papers focus on modeling analysis and implementation of dynamic and reactive systems involving both discrete and continuous behaviors *Handbook of Hybrid Systems Control* Jan Lunze, Françoise Lamnabhi-Lagarigue, 2009-10-15 Sets out core theory and reviews new methods and applications to show how hybrid systems can be modelled and understood

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Table of Contents Linear Systems Theory Hespanha Solutions

1. Understanding the eBook Linear Systems Theory Hespanha Solutions
 - The Rise of Digital Reading Linear Systems Theory Hespanha Solutions
 - Advantages of eBooks Over Traditional Books
2. Identifying Linear Systems Theory Hespanha Solutions
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Linear Systems Theory Hespanha Solutions
 - User-Friendly Interface
4. Exploring eBook Recommendations from Linear Systems Theory Hespanha Solutions
 - Personalized Recommendations
 - Linear Systems Theory Hespanha Solutions User Reviews and Ratings
 - Linear Systems Theory Hespanha Solutions and Bestseller Lists

5. Accessing Linear Systems Theory Hespanha Solutions Free and Paid eBooks
 - Linear Systems Theory Hespanha Solutions Public Domain eBooks
 - Linear Systems Theory Hespanha Solutions eBook Subscription Services
 - Linear Systems Theory Hespanha Solutions Budget-Friendly Options
6. Navigating Linear Systems Theory Hespanha Solutions eBook Formats
 - ePub, PDF, MOBI, and More
 - Linear Systems Theory Hespanha Solutions Compatibility with Devices
 - Linear Systems Theory Hespanha Solutions Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Linear Systems Theory Hespanha Solutions
 - Highlighting and Note-Taking Linear Systems Theory Hespanha Solutions
 - Interactive Elements Linear Systems Theory Hespanha Solutions
8. Staying Engaged with Linear Systems Theory Hespanha Solutions
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Linear Systems Theory Hespanha Solutions
9. Balancing eBooks and Physical Books Linear Systems Theory Hespanha Solutions
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Linear Systems Theory Hespanha Solutions
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Linear Systems Theory Hespanha Solutions
 - Setting Reading Goals Linear Systems Theory Hespanha Solutions
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Linear Systems Theory Hespanha Solutions
 - Fact-Checking eBook Content of Linear Systems Theory Hespanha Solutions
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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