

**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  $3 \times 3$  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

**Julio B. Clempner, Wen Yu**



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**Advances in Distributed Parameter Systems** Jean Auriol,Joachim Deutscher,Guilherme Mazanti,Giorgio Valmorbida,2022-04-24 The proposed book presents recent breakthroughs for the control of distributed parameter systems and follows on from a workshop devoted to this topic It introduces new and unified visions of the challenging control problems raised by distributed parameter systems The book collects contributions written by prominent international experts in the control community addressing a wide variety of topics It spans the full range from theoretical research to practical implementation and follows three traverse axes emerging ideas in terms of control strategies energy shaping prediction based control numerical control input saturation theoretical concepts for interconnected systems with potential non linear actuation dynamics advanced applications cable operated elevators traffic networks and numerical aspects Cutting edge experts in the field contributed in this volume making it a valuable reference source for control practitioners graduate students and scientists researching practical and theoretical solutions to the challenging problems raised by distributed parameter systems

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**Calculus of Variations and Optimal Control Theory** Daniel Liberzon,2012-01-08 This textbook offers a concise yet rigorous introduction to calculus of variations and optimal control theory and is a self contained resource for graduate students in engineering applied mathematics and related subjects Designed specifically for a one semester course

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**Linear System** Ferenc Szidarovszky,1997-11 **Advanced Topics in Control Systems Theory** Antonio Loría,Françoise Lamnabhi-Lagarrigue,Elena Panteley,2006-02-09 This book includes selected contributions by lecturers at the third annual Formation d Automatique de Paris It provides a well integrated synthesis of the latest thinking in nonlinear optimal control observer design stability analysis and structural properties of linear systems without the need for an exhaustive literature review The internationally known contributors to this volume represent many of the most reputable control centers in Europe

Cooperative Control of Multi-agent Systems Guanglei Zhao,Hailong Cui,Changchun Hua,Shuang Liu,2024-03-23 This book focuses on stability analysis and control design approaches for multi agent systems under network induced constraints A hybrid system approach is introduced to address the cooperative control problem of networked multi agent systems and several important topics such as asynchronous sampled data cooperative control hybrid event triggered cooperative control and reset based cooperative control are studied under the hybrid system framework The special feature of this book is that a hybrid systems approach is proposed for the cooperative control of multi agent systems which is beneficial for relaxing the conservativeness of stability analysis and network parameter computation Interested readers can learn a novel approach to cooperative control of multi agent systems and this book can benefit researchers engineers and graduate students in the fields of multi robot cooperation unmanned aerial vehicle formation control engineering etc

**Feedback Stabilization of Controlled Dynamical Systems** Nicolas Petit,2017-03-23 This book is a tribute to Professor Laurent Praly and follows on from a workshop celebrating the occasion of his 60th birthday It presents new and unified visions of the numerous problems that Laurent Praly has worked on in his prolific career adaptive control output feedback and observers stability and stabilization His main contributions are the central topic of this book The book collects contributions written by prominent international experts in the control community addressing a rich variety of topics emerging ideas advanced applications and theoretical concepts Organized in three sections the first section covers the field of adaptive control where Laurent Praly started his career The second section focuses on stabilization and output

feedback which is also the topic of the second half of his career Lastly the third section presents the emerging research that will form Laurent Praly's scientific legacy      Solutions Manual for "Linear System Theory and Design, Third Edition"  
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