

## SUBJECT INDEX

- actuator, 98
  - dynamics, 98
- adjoint
  - response, 18,38,78
  - variable, 38,45
  - vector, 83,89
- angle
  - of attack, 94,95,97
  - bank —, 94
  - engine power lever control —, 95
  - pitch —, 95
- Approach Power Compensation System (APCS), 93,100
  - servo, 99
- Automatic Carrier Landing System (ACLS), 93,103
  
- Banach space, 2,75
- bank angle, 94
- boundary
  - conditions, 80
  - value problem, 20–23,29,31,61,62, 77,81,83,89
  
- carrier air wake, 94
- closed loop system, 30,73,74,88,90,98
- condition
  - transversality —, 18,38
- conditions
  - boundary —, 80
  - necessary —, 1,5,6,10,73,77,90
  - saddle point —, 30,35
  - sufficient —, 74
  - transversality —, 9
- cone, 2,78
  - convex —, 2
  - dual —, 3,4,78
  
- control
  - feedback matrix, 97
  - variable, 93
  - finite horizon  $H_\infty$  suboptimal — problem, 86
  - $H_\infty$  —, 15
  - optimal —, 1,5,6
  - suboptimal  $H_\infty$  —, 35
- controller, 49,57,66,68,70,73,86,88,90
  - feedback —, 15,16,29,32,42
  - finite horizon  $H_\infty$  —, 12
  - $H_\infty$  —, 36,94
  - $H_\infty$  — design, 94
  - $H_\infty$  suboptimal —, 60
  - optimal —, 20,21
  - output feedback —, 16,35,36,42,50,94, 97,100,104
  - state feedback —, 16,28,31,37,39,58,88
  - suboptimal —, 35,36,50,53,54,58,70,88, 97,103
  - suboptimal finite horizon  $H_\infty$  —, 50,85
  - suboptimal  $H_\infty$  —, 1,36,37,53,54,66,73, 85
- convergence
  - Lebesgue dominated — theorem, 76
  - weak —, 76
- convex
  - cone, 2
  - functional, 16,35
- cost functional, 1,10,11,73,78,90
- criterion
  - performance —, 17,37
  
- Deck Motion Compensation (DMC), 93
- differential equation, 23,31
- direction
  - of decrease, 2,4,7,78
  - feasible —, 3,4,7
  - tangent —, 3,4,78,79

- dual
  - cone, 3,4,78
  - space, 3,4
  - system, 44
- Dubovitskii-Milyutin theorem, 4,78,80
- dynamics
  - actuator —, 98
  - engine —, 98,99,101
  - system —, 98
- eigenvalues, 30,98,100
- elemental variations, 83
- engine, 99
  - dynamics, 98,99,101
  - power lever control angle, 95,101
- equation
  - differential —, 23,31
  - Riccati —, 15,16,28,31,35,36,46,53,58,59,88,93,97
- error energy, 97
- Euclidean norm, 75
- existence theorem, 73
- exogenous input, 29,30,40,61,62,89
- F/A-18A, 93,94,96,103
- feasible direction, 3,4,7
- feedback
  - control — matrix, 97
  - full state —, 53
  - output —, 53,94,103
- feedback controller, 15,16,29,32,42
  - state —, 16,28,31,37,39,58,88
  - output —, 16,35,36,42,50,94,97,100,104
- finite horizon
  - $H_\infty$ , 53,73,93
  - $H_\infty$  controller, 12
  - $H_\infty$  norm, 22,25,73
  - $H_\infty$  optimal control, 15,30
  - $H_\infty$  performance robustness problem, 53,70,73,74,85,90
  - $H_\infty$  suboptimal control problem, 86
  - suboptimal  $H_\infty$  problem, 36
  - suboptimal —  $H_\infty$  controller, 50,85
- flight path angle, 93,94
- forward velocity, 95
- Fréchet derivative, 78,79
- functional
  - convex —, 16,35
  - cost —, 1,10,11,73,78,90
  - linear —, 3
  - nonstandard —, 1
  - support —, 3
- glide slope, 102
- $H_\infty$ 
  - finite horizon —, 53,73,93
  - finite horizon — norm, 22,25,73
  - finite horizon — performance robustness problem, 53,70,73,74,85,90
  - finite horizon — suboptimal control problem, 86
  - finite horizon suboptimal — problem, 36
  - control, 15
  - controller, 36,94
  - controller design, 94
  - design, 93
  - norm, 74,90
  - output feedback design, 101
  - performance robustness problem, 74,82
  - problem, 15,17,35
  - suboptimal controller, 60
  - suboptimal design, 94
  - infimal — norm, 15,25,31,53,94
  - suboptimal finite horizon — controller, 50,85
  - suboptimal — control, 35
  - suboptimal — controller, 1,36,37,53,54,66,73,85
  - suboptimal — problem, 36,53,55
- Hamiltonian, 18,38
- horizontal tail, 95,102

- identity matrix, 68,95
- infimal  $H_\infty$  norm, 15,25,31,53,94
- integral inequalities, 73
  
- leading edge flap, 95,99,101
- Lebesgue dominated convergence theorem, 76
- linear
  - functional, 3
  - system, 1,73
  - topological space, 2
- Lipschitz condition, 2,11
- longitudinal equations, 93
- longitudinal system, 96
- longitudinal velocity, 102
  
- maximum principle, 18,38,60
- matrix
  - control feedback —, 97
  - identity —, 68,95
  - transition —, 22,62
  - weighting —, 17
- minimax
  - problem, 17
  - solution, 19
- minimization problem, 73,74,90
  
- necessary conditions, 1,5,6,10,73,77,90
- nonlinear system, 1
- nonstandard functional, 1
- norm, 3
  - Euclidean —, 75
  - finite horizon  $H_\infty$  —, 22,25,73
  - $H_\infty$  —, 74,90
  - infimal  $H_\infty$  —, 15,25,31,53,94
  
- observer, 44,49,57,87
- optimal control, 1,5,6
- optimal controller, 20,21
- optimal trajectory, 30,61
  
- output feedback, 53,94,103
  - $H_\infty$  — design, 101
  - controller, 16,35,36,42,50,94,97, 100,104
  
- parameter
  - uncertainties, 53,54
  - variations, 53,54,63,64,67,70,74, 82,85
- performance
  - finite horizon  $H_\infty$  — robustness problem, 53,70,73,74,85,90
  - $H_\infty$  — robustness problem, 74,82
  - criterion, 17,37
  - degradation, 54
  - index, 36
  - robustness, 54,73,85
  - robustness problem, 54,66,67
  - suboptimal — robustness problem, 55,66, 90
  - variation, 85
- pitch
  - angle, 95
  - rate, 95
- power spectral density, 102,103
- principle
  - maximum —, 18,38,60
- problem
  - boundary value —, 20–23,29,31,61, 62,77,81,83,89
  - finite horizon  $H_\infty$  performance robustness —, 53,70,73,74,85,90
  - finite horizon  $H_\infty$  suboptimal control —, 86
  - $H_\infty$  —, 15,17,35
  - $H_\infty$  performance robustness —, 74,82
  - minimax —, 17
  - minimization —, 73,74,90
  - performance robustness —, 54,66,67
  - suboptimal  $H_\infty$  —, 36,53,55
  - suboptimal performance robustness —, 55,66,90
  
- radar, 93,103
- response
  - adjoint —, 18,38,78

- Riccati equation, 15,16,28,31,35,36,46,53,  
58,59,88,93,97
- robustness  
finite horizon  $H_\infty$  performance — pro-  
blem, 53,70,73,74,85,90  
 $H_\infty$  performance — problem, 74,82  
performance —, 54,73,85  
performance — problem, 54,66,67  
suboptimal performance — problem,  
55,66,90
- rudder, 99  
— toe-in, 95,101
- saddle point, 18,37  
— conditions, 30,35  
— solution, 19,39,45
- sensor noise, 93,94,102
- ship burble, 93,102,104
- sink rate, 102
- smooth manifolds, 9
- solution  
minimax —, 19  
saddle point —, 19,39,45
- space  
Banach —, 2,75  
dual —, 3,4  
linear topological —, 2
- stabilator, 99,101
- state  
full — feedback, 53  
— feedback controller, 16,28,31,37,39,  
58,88
- suboptimal controller, 35,36,50,53,54,58,70,  
88,97,103
- suboptimal finite horizon  $H_\infty$  controller,  
50,85
- suboptimal  $H_\infty$  control, 35
- suboptimal  $H_\infty$  controller, 1,36,37,53,54,  
66,73,85
- suboptimal  $H_\infty$  problem, 36,53,55
- suboptimal performance robustness prob-  
lem, 55,66,90
- sufficient conditions, 74
- support functional, 3
- supporting hyperplane, 3
- system  
closed loop —, 30,73,74,88,90,98  
dual —, 44  
linear —, 1,73  
longitudinal —, 96  
— dynamics, 98  
— matrices, 53,54,63,66,70,73,85,90,95  
time-invariant —, 53,59,88  
time-varying —, 16,27,36,55
- tangent direction, 3,4,78,79
- theorem  
Dubovitskii-Milyutin —, 4,78,80  
existence —, 73  
Lebesgue dominated convergence —, 76
- thrust, 93
- time-invariant system, 53,59,88
- time-varying system, 16,27,36,55
- transfer function, 97,102,103
- transition matrix, 22,62
- transversality  
— condition, 18,38  
— conditions, 9
- turbulence, 101,104
- variable  
adjoint —, 38,45
- variation  
performance —, 85
- variations  
elemental —, 83  
parameter —, 53,54,63,64,67,70,74,  
82,85
- vector  
adjoint —, 83,89  
— transpose, 17,37,55,95
- vertical burble, 101,102
- vertical gust, 93,94,95,101
- vertical rate command, 93,97,101
- weak convergence, 76
- weighting matrix, 17
- worst disturbance, 19

# Systems & Control: Foundations & Applications

## *Series Editor*

Christopher I. Byrnes  
School of Engineering and Applied Science  
Washington University  
Campus P.O. 1040  
One Brookings Drive  
St. Louis, MO 63130-4899  
U.S.A.

*Systems & Control: Foundations & Applications* publishes research monographs and advanced graduate texts dealing with areas of current research in all areas of systems and control theory and its applications to a wide variety of scientific disciplines.

We encourage the preparation of manuscripts in TEX, preferably in Plain or AMS TEX. LaTeX is also acceptable—for delivery as camera-ready hard copy which leads to rapid publication, or on a diskette that can interface with laser printers or typesetters.

Proposals should be sent directly to the editor or to: Birkhäuser Boston,  
675 Massachusetts Avenue, Cambridge, MA 02139, U.S.A.

Estimation Techniques for Distributed Parameter Systems  
*H.T. Banks and K. Kunisch*

Set-Valued Analysis  
*Jean-Pierre Aubin and Hélène Frankowska*

Weak Convergence Methods and Singularly Perturbed  
Stochastic Control and Filtering Problems  
*Harold J. Kushner*

Methods of Algebraic Geometry in Control Theory: Part I  
Scalar Linear Systems and Affine Algebraic Geometry  
*Peter Falb*

$H^\infty$ -Optimal Control and Related Minimax Design Problems  
*Tamer Başar and Pierre Bernhard*

Identification and Stochastic Adaptive Control  
*Han-Fu Chen and Lei Guo*

Viability Theory  
*Jean-Pierre Aubin*

Representation and Control of Infinite Dimensional Systems, Vol. I  
*A. Bensoussan, G. Da Prato, M. C. Delfour and S. K. Mitter*

Representation and Control of Infinite Dimensional Systems, Vol. II  
*A. Bensoussan, G. Da Prato, M. C. Delfour and S. K. Mitter*

Mathematical Control Theory: An Introduction  
*Jerzy Zabczyk*

$H_\infty$ -Control for Distributed Parameter Systems: A State-Space Approach  
*Bert van Keulen*

Disease Dynamics  
*Alexander Asachenkov, Guri Marchuk, Ronald Mohler, Serge Zuev*

Theory of Chattering Control with Applications to Astronautics,  
Robotics, Economics, and Engineering  
*Michail I. Zelikin and Vladimir F. Borisov*

Modeling, Analysis and Control of Dynamic Elastic  
Multi-Link Structures  
*J. E. Lagnese, Günter Leugering, E. J. P. G. Schmidt*

First Order Representations of Linear Systems  
*Margreet Kuijper*

Hierarchical Decision Making in Stochastic Manufacturing Systems  
*Suresh P. Sethi and Qing Zhang*

Optimal Control Theory for Infinite Dimensional Systems  
*Xunjing Li and Jiongmin Yong*

Generalized Solutions of First-Order PDEs: The Dynamical  
Optimization Process  
*Andrei I. Subbotin*

Finite Horizon  $H_\infty$  and Related Control Problems  
*M. Bala Subrahmanyam*