Contents

1 Introduction 1
Notes and References 20

2 Manifolds, Vectorfields, Lie Brackets, Distributions 23
2.0 Survey of Section 2.1 24
2.1 Manifolds, Coordinate Transformations, Tangent Space 29
2.1.1 Differentiability, Manifolds, Submanifolds 29
2.1.2 Tangent Vectors, Tangent Space, Tangent Mappings 37
2.2 Vectorfields, Lie Brackets, Distributions, Frobenius' Theorem, Differential One-Forms 43
2.2.1 Vectorfields, Lie Brackets, Lie Algebras 43
2.2.2 Distributions, Frobenius' Theorem 55
2.2.3 Cotangent Bundle, Differential One-Forms, Co-distributions 61
2.3 Summary of Section 2.2 67
Notes and References 69
Exercises 70

3 Controllability and Observability, Local Decompositions 73
3.1 Controllability 73
3.2 Observability 93
3.3 Invariant Distributions; Local Decompositions 101
Notes and References 111
Exercises 113

4 Input-Output Representations 117
4.1 Wiener-Volterra and Fliess Series Expansion 118
4.2 External Differential Representations 125
4.3 Output Invariance 135
Notes and References 143
Exercises 145

5 State Space Transformation and Feedback 148
5.1 State Space Transformations and Equivalence to Linear Systems 148
5.2 Static and Dynamic Feedback 165
Notes and References 172
Exercises 173

Bibliografische Informationen
http://d-nb.info/920409288

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

6 Feedback Linearization of Nonlinear Systems 176
6.1 Geometric Conditions for Feedback Linearization 178
6.2 Computational Aspects of Feedback Linearization 194
Notes and References 205
Exercises 207

7 Controlled Invariant Distribution and the Disturbance Decoupling Problem 211
7.1 Controlled Invariant Distributions 211
7.2 The Disturbance Decoupling Problem 219
Notes and References 237
Exercises 239

8 The Input-Output Decoupling Problem 242
8.1 Static State Feedback Input-Output Decoupling for Analytic Systems 242
8.2 Dynamic State Feedback Input-Output Decoupling 255
Notes and References 270
Exercises 271

9 The Input-Output Decoupling Problem: Geometric Considerations 274
9.1 The Block Input-Output Decoupling Problem for Smooth Nonlinear Systems 274
9.2 The Formal Structure at Infinity and Input-Output Decoupling 286
Notes and References 294
Exercises 296

10 Local Stability and Stabilization of Nonlinear Systems 299
10.1 Local Stability and Local Stabilization via Linearization 299
10.2 Local Stabilization using Lyapunov's Direct Method 303
10.3 Local Stabilization via Center Manifold Theory 310
Notes and References 319
Exercises 321

11 Controlled Invariant Submanifolds and Nonlinear Zero Dynamics 323
11.1 Locally Controlled Invariant Submanifolds 323
11.2 Constrained Dynamics and Zero Dynamics 331
11.3 Interconnection of Systems and Inverse Systems 337

Notes and References 344
Exercises 346

12 Mechanical Nonlinear Control Systems 349
12.1 Definition of a Hamiltonian Control System 355
12.2 Controllability and Observability; Local Decompositions 363
12.3 Stabilization of Hamiltonian Control Systems 369
12.4 Constrained Hamiltonian Dynamics 376
12.5 Conservation Laws and Reduction of Order 385
Notes and References 392
Exercises 394

13 Controlled Invariance and Decoupling for General Nonlinear Systems 400
13.1 Locally Controlled Invariant Distributions 400
13.2 Disturbance Decoupling 414
13.3 Input-Output Decoupling 416
13.4 Locally Controlled Invariant Submanifolds 422
13.5 Control Systems Defined on Fiber Bundles 426
Notes and References 431
Exercises 433

14 Discrete-Time Nonlinear Control Systems 437
14.1 Feedback Linearization of Discrete-Time Nonlinear Systems 438
14.2 Controlled Invariant Distributions and the Disturbance Decoupling Problem in Discrete-Time 445
14.3 Input-Output Decoupling in Discrete-Time 451
Notes and References 459
Exercises 461

Subject Index 463