
Contents

Part I Basic concepts

1	Systems	3
1.1	System definition	3
1.2	System behavior	6
1.3	Examples	8
1.4	Composing systems	19
1.5	Notes	21
2	Verification problems	23
2.1	$S_a \cong S_b$	23
2.2	$S_a \preceq S_b$	24
3	Control problems	25
3.1	$S_c \times_{\mathcal{I}} S_a \cong S_b$	25
3.2	$S_c \times_{\mathcal{I}} S_a \preceq S_b$	26

Part II Finite systems

4	Exact system relationships	29
4.1	Behavioral relationships	30
4.2	Similarity relationships	33
4.3	Alternating similarity relationships	40
4.4	Notes	42
5	Verification	43
5.1	Behavioral relations	43
5.2	Similarity relations	45
5.3	Notes	50

6 Control	51
6.1 Feedback composition	52
6.2 Safety games	55
6.3 Reachability games	61
6.4 Behavioral games	64
6.5 Similarity games	64
6.6 Notes	70

Part III Infinite Systems: Exact symbolic models

7 Exact symbolic models for verification	73
7.1 Dynamical and hybrid dynamical systems as systems	74
7.2 Timed automata	80
7.3 Order minimal hybrid dynamical systems	87
7.4 Sign based abstractions	94
7.5 Barrier certificates	103
7.6 Computation of reachable sets	105
7.7 Advanced topics	109
7.8 Notes	110
8 Exact symbolic models for control	113
8.1 Control systems as systems	114
8.2 Controller refinement	117
8.3 Discrete-time linear control systems	118
8.4 Continuous-time multi-affine control systems	133
8.5 Notes	142

Part IV Infinite Systems: Approximate symbolic models

9 Approximate system relationships	145
9.1 Approximate similarity relationships	145
9.2 Approximate alternating similarity relationships	148
9.3 Notes	149
10 Approximate symbolic models for verification	151
10.1 Stability of linear dynamical systems	152
10.2 Dynamical systems as systems	155
10.3 Symbolic models for affine dynamical systems	156
10.4 Advanced topics	163
10.5 Notes	166

11 Approximate symbolic models for control	167
11.1 Stability of linear control systems	168
11.2 Control and switched systems as systems	170
11.3 Approximate feedback composition and controller refinement ..	172
11.4 Symbolic models for affine control systems	175
11.5 Symbolic models for switched affine systems	183
11.6 Advanced topics	186
11.7 Notes	189
Appendix	191
A.1 Lattice theory	191
A.2 Fixed-points	192
References	195
Index	201