

Contents

1	Inert and inhabited dynamical systems	1
1.1	Topic	1
1.1.1	The two levels of system description	3
1.1.2	Perception	4
1.1.3	Inertia	6
1.1.4	Actions	7
1.1.5	Inhabited dynamical systems and AI	8
1.2	The image level of description	9
1.2.1	Structure of an IDS	9
1.2.2	Fluents and occurrences	10
1.2.3	The monitor	12
1.3	Ego/world interaction	14
1.3.1	Informal introduction to ego/world interaction	15
1.3.2	Finite, infinite, and complete developments	17
1.3.3	Egos and worlds	19
1.3.4	IDS Games	21
1.3.5	Formal IDS's	22
1.3.6	Scenarios	23
1.4	The ontological taxonomy	24
1.4.1	Ontological designators	24
1.4.2	The ontological characteristics	25
1.4.3	Ontological subfamilies	28
1.4.4	Assignment of ontological family to a problem	29
1.5	Summary	29
2	Inference operations on scenario descriptions	31
2.1	Scenario descriptions	31
2.1.1	The Stockholm delivery scenario	32
2.1.2	IDS scenarios vs. common-sense scenarios	32
2.1.3	Structure of scenario descriptions	34
2.1.4	Object domains	37
2.1.5	Timepoint and object constants	37
2.1.6	Chronicles	38
2.2	Epistemological assumptions	39

2.2.1	Logics with implicit epistemological assumptions	39
2.2.2	Epistemological designators	41
2.2.3	The repertoire of epistemological designators	43
2.3	Formal definitions of scenario descriptions	43
2.3.1	Scenario descriptions	43
2.3.2	Model sets for scenario descriptions	46
2.4	Entailment relations	47
2.4.1	Entailment relations and weakened models	47
2.4.2	Scenario completion	48
2.4.3	Deduction and abduction with respect to chronicles	49
2.4.4	Consistency-checking with respect to chronicles	51
2.4.5	Chronicle completion as the pivotal operation	52
2.5	Reasoning problems	53
2.5.1	Definitions of reasoning problems	53
2.5.2	Rephrasing logical operations as reasoning problems	54
2.5.3	Discussion	57
2.6	Terminology	58
2.6.1	Domains and worlds	58
2.6.2	Formulae, axioms, and premises	59
2.6.3	Layers of logic and of logical language	59
2.6.4	Realizations and implementations	61
2.7	Summary	61
3	Underlying semantics for IDS worlds	63
3.1	Some methodological aspects of common-sense reasoning	63
3.1.1	The example-based methodology	63
3.1.2	Systematic methodology used in this book	65
3.1.3	Approaching common-sense reasoning with systematic methodology	67
3.1.4	Combining the two methodologies	69
3.1.5	The progression of more general ontologies	69
3.1.6	Syntax based assessment methodology	71
3.1.7	Validation using a chronicle description language	72
3.2	Choice of underlying semantics	72
3.2.1	Reasons for IDS world semantics	72

3.2.2	Partial state-transition semantics	73
3.2.3	Trajectory semantics	75
3.2.4	Trajectory-semantics worlds	75
3.2.5	Trajectory-semantics egos	78
3.2.6	Trajectory semantics and ontological families	78
3.3	Trajectory semantics in concrete terms	79
3.3.1	The rainy-day shooting example	79
3.3.2	The bus ride example	80
3.4	Trajectories and the material system	80
3.5	Summary	82
4	Elementary feature logic and meta-logical concepts	83
4.1	Logical domains	83
4.1.1	Object domain vs. value domains	84
4.1.2	Lexical object domains	84
4.2	Elementary feature logic	86
4.2.1	Introduction	86
4.2.2	Value domains and syntax	87
4.2.3	Semantics	89
4.2.4	Some axioms	89
4.3	Meta-level concepts in the base logics	90
4.3.1	Meta-level domains and the model set	90
4.3.2	Quine quotes	90
4.3.3	Meta-level operations	91
4.3.4	Abbreviations	91
4.3.5	Logical entailment relations	91
4.4	Reduction of model sets	92
4.4.1	Selection functions	93
4.4.2	Alternatives to selection functions	94
4.4.3	Semantic selection and selection functions	94
4.4.4	Syntactic methods and premise integration	97
4.5	Summary	99
5	Lexical-domain object-feature logic	100
5.1	Ontology	100
5.1.1	Object domains	100
5.1.2	Features	101
5.2	Basic definitions	101
5.2.1	Object domains, similarity types, and vocabularies	101
5.2.2	Syntax	102

5.2.3	Denotations	103
5.2.4	Valuation of formulae	104
5.2.5	Model sets and entailment	106
5.3	An example	106
5.3.1	The assignment scenario	107
5.3.2	The elementary codesignation algorithm	109
5.4	Set-level approach	112
5.4.1	Syntax and semantics	112
5.4.2	Axioms	113
5.4.3	The assignment scenario revisited	113
5.4.4	Example ‘mother of son’	114
5.5	Summary	115
6	Temporal feature logic for discrete time domains	116
6.1	Ontology for standard time	117
6.1.1	Choice and use of time domain	117
6.1.2	Rationale for standard time	118
6.1.3	Timepoints	119
6.1.4	States	120
6.1.5	Situations	120
6.1.6	Arguments in favor of non-metric time	121
6.1.7	Intra-situation change and chronometric fluent	122
6.1.8	Time structure	123
6.1.9	Non-determinism in Herbrand time	124
6.2	Reification of temporal formulae	125
6.3	Main syntax	127
6.3.1	Core of the main syntax for DFL-1	128
6.3.2	Convenience abbreviations	130
6.4	Semantics and axioms for the base logic	132
6.4.1	Semantics	132
6.4.2	Some axioms	134
6.5	The side language for occurrences	134
6.5.1	Approach	134
6.5.2	The elementary occurrence language	135
6.5.3	Reassignment formulae as abbreviations	137
6.6	Branching time	138
6.6.1	The linear and branching time domains	138
6.6.2	Intervals and trees in branching time	140
6.6.3	Inhabited dynamical systems with branching time	142
6.7	Summary	146

7	Chronicle completion in \mathcal{K} -IA	147
7.1	Chronicle completion	147
7.2	Examples of chronicle completion in common-sense domains	150
7.2.1	Yale shooting scenario (YSS)	151
7.2.2	Hiding turkey scenario (HTS)	152
7.2.3	Stanford murder mystery (SMM)	154
7.2.4	Ferryboat connection scenario (FCS)	154
7.2.5	Russian turkey scenario (RTS)	155
7.2.6	Stolen car scenario (SCS)	156
7.2.7	Ticketed car scenario (TCS)	157
7.2.8	Furniture assembly scenario (FAS)	158
7.3	The IA family of IDS worlds	159
7.3.1	Definition of the IA ontological family	159
7.3.2	Subcharacteristics for I	162
7.3.3	Subcharacteristics for A	165
7.4	The \mathcal{K} -IA family of chronicles	167
7.4.1	Epistemological properties	167
7.4.2	Classification of scenario examples	168
7.5	Summary	168
8	Intended models for chronicles in \mathcal{K} -IA	169
8.1	Full trajectory normal form for action laws	169
8.1.1	An example	169
8.1.2	Action laws for actions without arguments	171
8.1.3	Action laws for actions with arguments	173
8.1.4	Expressiveness of FTNF for infinite trajectory sets	174
8.2	Chronicle structure in \mathcal{K} -IA	175
8.2.1	The schedule in a chronicle	175
8.2.2	The observation set in a chronicle	176
8.2.3	The action laws in a chronicle	177
8.2.4	Definition of \mathcal{K} -IA chronicles	178
8.2.5	The labelled-formula layout	178
8.3	Truth conditions for chronicles	180
8.3.1	Auxiliary concepts	180
8.3.2	Model set for an IA chronicle	182
8.3.3	Intended model set for an IA chronicle	185
8.3.4	Classical models for an IA chronicle	185
8.3.5	Chronicle completion	186
8.4	Models over restricted time domains	187
8.4.1	Definitions and basic properties	187

8.4.2	Progressive construction of restricted intended models	189
8.5	Adaptations for branching time	191
8.5.1	Chronicle structure	191
8.5.2	Truth conditions for chronicles	192
8.6	Summary	193
9	Entailment methods for \mathcal{K}-IA using DFL-1	194
9.1	Entailment methods	195
9.1.1	Pretransformations and model selection	195
9.1.2	Entailment methods formed using minimization	196
9.1.3	Prototypical chronological minimization of change	198
9.1.4	Original chronological minimization of change	199
9.1.5	Prototypical global minimization of change	200
9.2	Assessments of applicability	201
9.2.1	Time-restricted selection functions	202
9.2.2	Assessment of PCM	203
9.2.3	Assessment of OCM	206
9.2.4	Assessment of PGM	208
9.2.5	Discussion of the restrictions	209
9.3	Discussion of possible improvements	211
9.3.1	Ambiguities	211
9.4	Entailment methods that use filtering, and their assessments	213
9.4.1	Definitions	213
9.4.2	Assessments	214
9.5	Branching time	215
9.6	Summary	215
10	Duration constraints	217
10.1	Chronological assignment of valuation	217
10.1.1	Discussion	217
10.1.2	The model selection function for CAMC	218
10.1.3	Reformulation functions	219
10.2	Intended models using executable schedules	220
10.2.1	Executable schedules	221
10.2.2	Auxiliary concepts	223
10.2.3	Performing egos	224
10.2.4	Finite intended model sets	226
10.3	Assessment of applicability for CAMC	228

10.3.1	Auxiliary definitions	228
10.3.2	Assessment	228
10.4	Generalization to branching time	230
10.5	Summary	231
11	Entailment methods for \mathcal{K}-IA using occlusion	232
11.1	Discussion	232
11.1.1	Change incidence ambiguity	232
11.1.2	Changetime ambiguity	235
11.2	Minimization of occlusion	237
11.2.1	Syntax extensions for DFL-2	238
11.2.2	Semantics extensions for DFL-2	238
11.2.3	Correctness condition	239
11.3	Chronological entailment methods with occlusion	239
11.3.1	Chronological minimization of occlusion and change	240
11.3.2	Chronological assignment of valuation and minimization of occlusion and change	241
11.4	Syntactical approaches with occlusion	241
11.4.1	Schema of nochange break premises	241
11.4.2	Global minimization of occlusion with nochange premises	242
11.4.3	Pointwise minimization of occlusion with nochange premises and filtering	243
11.5	Two-stage minimization of occlusion and change	244
11.6	Assessments of occlusion-based approaches	244
11.6.1	Assessment of CAMOC	244
11.6.2	Assessment of CMOC	246
11.6.3	Assessments of methods that use nochange premises	247
11.6.4	Assessments of a two-stage entailment method	250
11.6.5	Summary	251
11.7	Oracle features	251
11.7.1	The oracle reformulation function	251
11.7.2	Entailment methods using oracles	253
11.7.3	Discussion	254
11.8	A perspective on the chronicle description language \mathcal{A}	255
11.9	Interpretation of assessment results	257
11.9.1	General remarks	257
11.9.2	The compatibility requirements	257
11.9.3	The special case of single-step actions	258

12 Composite actions	261
12.1 Composite actions in schedules	261
12.1.1 Syntax extension	262
12.1.2 Intended models	262
12.1.3 Direct translation of composite action statements	264
12.1.4 World descriptions for composite action statements	266
12.1.5 Aggregation	268
12.1.6 Widened translation of composite action statements	269
12.2 Entailment methods for chronicles containing composite action statements	273
12.2.1 Requirements for the generalized applicability of entailment methods	273
12.2.2 Entailment methods using Π^{kw}	274
12.2.3 Entailment methods using Π^k	275
12.3 Summary	275
13 Upper applicability bounds and assessment of soundness	276
13.1 Direct upper bounds	276
13.2 Principles for upper bounds for range of applicability	277
13.2.1 Merely ontological constraints	277
13.2.2 Ontological constraints in an epistemological range	278
13.2.3 Upper bounds on the epistemological constraints	279
13.2.4 Summary of the upper-bound results in this section	283
13.3 Additional upper bounds on range of applicability	283
13.3.1 Original chronological minimization	283
13.3.2 Prototypical global minimization	284
13.3.3 Global minimization of occlusion with nochange premises	286
13.4 Summary of upper-bound results	287
13.5 Assessments of soundness	289
13.6 Summary of assessment criteria and assessment results	290
14 Future directions	292

A	Term index	297
A.1	Abbreviations	297
A.2	Technical terms	299
B	Notation	311
C	References to related work	321