

Contents

I	Preliminaries	1
1	Introduction	3
1.1	Motivation	3
1.2	Problem Statement	4
1.3	Scenarios	6
1.3.1	RoboCup	7
1.3.2	Exploration	8
1.3.3	Rescue	8
1.4	Approach	9
1.5	Contributions	10
1.6	Structure of this Work	11
1.7	Conventions	12
2	Foundations	13
2.1	Agents	13
2.2	Multi-Agent Systems	15
2.3	Teamwork	17
2.4	Constraint Programming	18
3	Related Work	21
3.1	Action Calculi	21
3.2	BDI Languages	22
3.3	Plan Execution Languages	23
3.4	Teamwork	25
3.5	Task and Role Allocation	28
3.6	Estimating Agreement and Conflict Resolution	30
3.7	Task Models	31
3.8	Constraint-Based Modelling	32

II	Propositional ALICA	33
4	Syntax	35
4.1	Behaviours	36
4.2	Plans	38
4.3	Synchronisations	44
4.4	Roles	45
4.5	Well-Formedness	46
4.6	Overview of the Syntactic Elements in pALICA	48
5	Semantics	51
5.1	Fundamental Principles	51
5.2	Agent Model	53
5.2.1	Plan Base	54
5.2.2	Belief Base	55
5.2.3	Belief Update	59
5.2.4	Execution Set	60
5.2.5	Role Set	60
5.3	Locality	60
5.4	Team Configuration	61
5.5	Success Semantics	62
5.6	Role Allocation	63
5.7	Canonical Behaviour Plans	66
5.8	Task Allocation	67
5.9	Recursive Task Allocation	69
5.10	Optimal Task Allocation	79
5.11	Utility Functions	80
5.12	Task Allocation Algorithm	81
5.13	Rules	91
5.13.1	Operational Rules	93
5.13.2	Repair Rules	97
5.14	Agent Configuration Consistency	106
5.15	Summary	110
6	Conflict Detection and Resolution	113
6.1	Conflict Detection	113
6.2	Conflict Resolution	118

7	Software Architecture	127
7.1	Modelling Tools and Exchange Format	127
7.2	Engine Layout	128
7.3	Agent Software Architecture	130
7.4	Implementation Details	132
7.5	Communication	132
7.5.1	Information Exchange	133
7.5.2	Estimating the Current Team	134
7.6	Summary	137
III	General ALICA	139
8	Generalising ALICA	141
8.1	Introduction	141
8.1.1	Standard Situations	141
8.1.2	Blocks World	144
8.2	Behaviour Parameters and Plan Variables	145
8.3	Agent Variables	148
8.4	Constraints in ALICA	150
8.5	Constraint Store	154
8.6	Rules	155
8.6.1	Lifting Propositional ALICA Rules	155
8.6.2	Constraint Handling Rules	158
8.7	Queries	159
8.8	Summary	162
9	Solving Constraint Problems	165
9.1	Exemplary Constraint Satisfaction Problems	165
9.2	Non-Linear Continuous Constraint Satisfaction Problems	167
9.3	SMT-Solvers Revisited	170
9.4	Realtime Considerations	175
9.5	Coordination	178
9.6	Constraint Optimisation	185
9.7	Constraints and Task Allocation	187
9.8	Summary	190

IV Assessment	193
10 Evaluation	195
10.1 Modelling in RoboCup	195
10.1.1 Strong and Weak Synchronisation	196
10.1.2 Finite State Machines and Dynamic Task Allocation . . .	197
10.1.3 Select and Commit	198
10.2 Unreliable Communication	199
10.3 Constraint Solving and Optimisation	207
10.3.1 The Ring Problem	208
10.3.2 Blockers	210
10.3.3 Inverse Kinematics	213
10.3.4 Summary	215
10.4 Case Study: Exploration	216
10.4.1 Retrieving	217
10.4.2 Exploration	220
10.4.3 Summary	224
10.5 Rescue Simulation	224
11 Conclusion	235
11.1 Requirements Revisited	236
11.2 Outlook and Future Work	237
Bibliography	239

Modelling and Controlling of Behaviour for Autonomous
Mobile Robots

Skubch, H.

2013, XVII, 259 p. 46 illus., 16 illus. in color., Softcover

ISBN: 978-3-658-00810-9