Contents

I Introduction and Objectives **1**

1 Introduction and Objectives **3**
1.1 Characterising Transportation Enhancement 4
1.2 Artificial Intelligence for Transportation 7
1.3 Motivation 9
1.4 Objectives 12
1.5 Structure of the Thesis 13
1.6 List of Publications 16
1.7 Research Projects 19
1.8 Research Grants 20

II Transportation Simulation **21**

2 Data Generators for Agent-based Simulations **23**
2.1 Introduction 24
2.2 Related Work 25
2.3 Extending the SimFleet Simulator 28
2.4 Charging Stations Generator 30
2.5 Mobility Data Generator 40
2.6 Case Study 46
2.7 Conclusions 58

3 Taxi versus Carsharing Services: A Case Study in Valencia **59**
3.1 Introduction 60
3.2 Materials and Methods 63

3.3 Results 71
3.4 Discussion 79
3.5 Conclusions 82

III Urban Transportation Enhancement 85

4 Best-Response Planning for Urban Fleet Coordination 87
4.1 Introduction 88
4.2 Related Work 90
4.3 System Overview 94
4.4 Urban Mobility Planning Scenario 97
4.5 Ad-hoc Planner 101
4.6 Best-response Planning 104
4.7 Experimental Results 106
4.8 Discussion 121
4.9 Conclusions 124

5 Self-interested Demand-Responsive Shared Transportation 127
5.1 Introduction 128
5.2 Related Work 130
5.3 Overview 135
5.4 Static Subsystem 139
5.5 Dynamic Subsystem 144
5.6 Discussion 146
5.7 Conclusions 147

IV Rural and Interurban Transportation Enhancement 149

6 Demand-Responsive Transportation for Rural and Interurban Mobility 151
6.1 Introduction 152
6.2 Definitions and Problem Description 153
6.3 State of the Art Classification 157

6.4 Discussion 170
6.5 Conclusions 178

7 Flexible Approach for Rural Demand-Responsive Public Transport 181
7.1 Introduction 182
7.2 Demand-Responsive Transportation Description 184
7.3 System Proposal 189
7.4 Experimental Results 199
7.5 Discussion 207
7.6 Conclusion 209

V Discussion 211

8 Discussion 213
8.1 Contributions to Transportation Simulation 213
8.2 Contributions to Urban Transportation Enhancement 215
8.3 Contributions to Rural Transportation Enhancement 217
8.4 Limitations 219

VI Conclusions and Future Work 221

9 Conclusions and Future Work 223
9.1 Conclusions 223
9.2 Future Work 225

Bibliography 229

List of Figures

1.1 Core Components of Transportation. 5

2.1 Random distribution of stations. 31
2.2 Uniform distribution of stations process. 34
2.3 Radial distribution of stations process. 35
2.4 Genetic distribution of stations example. 40
2.5 Randomly generated routes in Manhattan. 42
2.6 Number of available points according to map division granularity. . . 43
2.7 50 routes examples in Manhattan with different granularity. 45
2.8 Manhattan population and traffic. 48
2.9 Charging stations in Manhattan obtained by the genetic-based generator. 51
2.10 Restricted set of taxi zones of the Manhattan borough. 55

3.1 Evolution of waiting and unsatisfied clients in carsharing simulations. 73
3.2 Evolution of waiting and unsatisfied clients in taxi simulations. 75

4.1 Operation of the Best-Response Fleet Planner. 96
4.2 Problem configuration visualised in SimFleet. 109
4.3 Agent charging intervals with no charging congestion costs. 119
4.4 Agent charging intervals with default charging congestion costs. . . . 119
4.5 Agent charging intervals with high charging congestion costs. 120
4.6 Power network usage with default charging congestion costs. 121
4.7 Power network usage with high charging congestion costs 121

5.1 System architecture. 138

6.1 Operational patterns for rural demand-responsive transportation systems. 154
6.2 Different configurations of demand-responsive transportation systems. 164

7.1 Observed use cases for rural demand-responsive transportation systems. 186
7.2 Operation modes of the transportation system scheduler. 190
7.3 Rural sub-area chosen for the deployment of the system. 200
7.4 Bus lines and stops of the public interurban bus service. 201
7.5 Final distribution of 99 stops over the chosen deployment area. 202
7.6 Visualisation of service quality. 207

List of Tables

2.1 Example of a probability distribution among 3 points. 44
2.2 Monetary cost of each of the charging station distributions in Manhattan. 52
2.3 Genetic algorithm results. 52
2.4 Clean taxi service dataset. 54
2.5 Dataset formatted to train a regression model. 54
2.6 Best pipeline found for our dataset. 56
2.7 Regression data prediction. 57

3.1 Description of the output metrics of the simulation. 69
3.2 Mobility demand per hour. 70
3.3 Simulation metrics of carsharing configurations. 72
3.4 Comparison of global simulation metrics of the different taxi fleets. . . 76
3.5 Simulation metrics comparison of the hybrid simulations. 78

4.1 Visual representation of a joint plan. 100
4.2 Station usage table example. 102
4.3 Problem instances used for experimentation. 108
4.4 Default values for the problem variables. 110
4.5 Average performance of the algorithm. 111
4.6 Solution quality comparison. 114
4.7 Cost reduction percentages. 115
4.8 Costs and congested agents according to resource bound. 117
4.9 Mean costs and congested agents. 118

5.1 Review of DRT system configurations. 133

6.1 Classification of surveys and analytical works. 171
6.2 Classification of experimental works. 172

7.1 Service quality evolution with fixed fleet. 205
7.2 Service quality evolution with ranging fleet size. 206
7.3 Lower bound of acceptable service quality. 206