Contents

Foreword **xvii**

1 Introduction **1**
1.1 Motivation 1
1.2 Taxonomy of Virtual Institutions 8
1.3 Research Problem 10
1.4 Objectives 12
1.5 Research Method 12
1.6 Contributions and Significance 14
1.6.1 Contributions 14
1.6.2 Significance 14
1.7 Structure 16

2 Background **19**
2.1 Virtual Worlds 19
2.1.1 Interactivity 19
2.1.2 Collaboration 20
2.1.3 Definitions and Terminology 20
2.1.4 Benefits of Using Avatars 22
2.1.5 Historical Overview of Virtual Worlds 23
2.1.6 Enabling Technologies 24
2.2 A Need for a Methodology 37
2.2.1 Methodologies in Computer Science 38
2.2.2 Methodologies for Virtual Worlds 39
2.3 Virtual Worlds as Multiagent Systems 41
2.4 Need for Institutions in Virtual Worlds 43
2.5 Electronic Institutions 45
2.5.1 Interactions of Participants in Electronic Institutions 46
2.5.2 Specification 47
2.5.3 EIDE Framework 49
2.5.4 Example: Trading Institution 50
2.5.5 Humans and Agents in Electronic Institutions 60
2.6 Summary 62

http://libros.csic.es

3 Virtual Institutions **63**
3.1 The Concept . . . 63
3.2 The Metaphor . . . 65
3.3 Visual Interaction Layer . . . 68
3.3.1 3D Interaction Space . . . 68
3.3.2 Garden . . . 68
3.3.3 Institutional Buildings . . . 68
3.3.4 Avatars . . . 69
3.3.5 Rooms . . . 71
3.3.6 Doors . . . 71
3.3.7 Map . . . 72
3.3.8 Backpack with obligations . . . 72
3.3.9 Events/Actions/Messages . . . 72
3.4 Normative Control Layer . . . 73
3.4.1 Federations . . . 73
3.4.2 Institutions . . . 73
3.4.3 Scenes and Transitions . . . 75
3.4.4 Performative Structure . . . 75
3.4.5 Connections . . . 76
3.4.6 Obligations . . . 76
3.4.7 Data Types in Ontology . . . 76
3.4.8 Illocutions and Messages . . . 77
3.4.9 Synchronization Issues . . . 77
3.5 Concept Illustration: Trading Institution . . . 78
3.6 Formalizing the Concept using Z Specification Language . . . 83
3.6.1 Virtual Institution Terms . . . 85
3.6.2 Virtual Institution Model . . . 87
3.6.3 The State of a Virtual Institution at Run Time . . . 99
3.6.4 Initialization of the States . . . 106
3.6.5 Operations . . . 109
3.7 Summary . . . 115

4 Approach and Methodology **117**
4.1 Virtual Institutions Methodology . . . 117
4.2 Technological Solution . . . 123
4.2.1 Step 4. Automatic Generation of Virtual Institutions . . . 124
4.2.2 Step 5. Annotation . . . 134
4.2.3 Step 6. Integration . . . 137
4.3 Deployment . . . 140
4.3.1 Normative Control Layer . . . 142
4.3.2 Visual Interaction Layer . . . 143
4.3.3 Communication Layer . . . 143
4.4 Summary . . . 151

http://libros.csic.es

5 Learning Aspects **153**
5.1 Related Work . . . 156
5.2 Implicit Training . . . 159
5.2.1 Scenario . . . 159
5.2.2 Visual and Normative Levels of Execution . . . 161
5.2.3 Learning to Imitate the Human . . . 162
5.2.4 Assessing the Cognitive State . . . 163
5.2.5 Distributed User Modeling . . . 165
5.3 Implementation Details . . . 167
5.3.1 Comparing the Trajectories . . . 167
5.3.2 Recording . . . 169
5.3.3 Using the Learning Graph . . . 172
5.3.4 Nearest Neighbor Classifier . . . 173
5.3.5 Detecting the Visibility of Objects . . . 174
5.4 Experiments . . . 175
5.4.1 Experiment 1: Trajectory Recognition . . . 176
5.4.2 Experiment 2: Training the External Agent . . . 180
5.5 Training the Internal Agent . . . 185
5.6 Summary . . . 188

6 Virtual Institutions in E-Commerce **191**
6.1 Issues in Existing E-Commerce Solutions and the Potential of Virtual Institutions in Addressing Them . . . 191
6.1.1 Drawbacks of Existing E-Commerce Solutions . . . 192
6.1.2 Beneficial Aspects of Virtual Institutions . . . 201
6.2 Developing a Virtual Institution for E-Tourism . . . 204
6.2.1 Selecting the Application Domain . . . 204
6.2.2 Eliciting Specification Requirements . . . 211
6.2.3 Developing the Normative Control Layer . . . 219
6.2.4 Developing the Visual Interaction Layer . . . 225
6.3 Summary . . . 226

7 Conclusion and Future Work **229**
7.1 Future Work . . . 230
7.1.1 Design Grammars . . . 230
7.1.2 Gestures . . . 231
7.1.3 Institutional Rules and Natural Language . . . 231
7.1.4 Introducing Implicit Social Conventions . . . 231
7.1.5 Evolution of Virtual Institutions . . . 232
7.1.6 Normative Virtual Environments . . . 232
7.1.7 Learning . . . 233
7.1.8 Agent Programming . . . 234
7.1.9 World Trotter Institution Prototype . . . 234
7.1.10 Other Application Domains . . . 235

http://libros.csic.es

A Z Specification of Electronic Institutions **237**
A.1 Electronic Institution Static Data Structures . . . 237
A.1.1 Basics: Variables, Constants, Terms, Ontology, Language . . . 237
A.1.2 The Social Model . . . 240
A.1.3 The Communication Model . . . 242
A.1.4 The Normative Model . . . 243
A.1.5 The Performative Model . . . 244
A.1.6 Standard Constraints on Performative Models . . . 248
A.1.7 The Electronic Institution . . . 251
A.2 The State of an Electronic Institution at Run Time . . . 252
A.2.1 Properties and Environments . . . 252
A.2.2 Social Model State . . . 253
A.2.3 Normative Model State . . . 254
A.2.4 Performative Model State . . . 254
A.2.5 The Electronic Institution State . . . 258
A.3 Electronic Institution Operations . . . 258
A.3.1 Operations on Scene Instances . . . 259
A.3.2 Operations on Transition Instances . . . 260
A.3.3 Dialogue Moves . . . 260
A.3.4 Operations on the Performative Model State . . . 262

B ISLANDER Specification Example: Trading Institution **265**

http://libros.csic.es