

# **Explaining Behaviour**

Using Qualitative Simulation in  
Interactive Learning Environments

# Contents

---

<b>Acknowledgements</b>	<b>ix</b>
<b>1 Introduction</b>	<b>1</b>
1.1 The Philosophy of Explanation . . . . .	1
1.2 Interactive Learning Environments . . . . .	2
1.3 Qualitative Simulation in Education . . . . .	3
1.4 Explanation Generation and Visualization . . . . .	4
1.5 Research Goals . . . . .	6
1.6 The Structure of this Thesis . . . . .	6
<b>2 Visualization of Qualitative Simulations</b>	<b>7</b>
2.1 The GARP Framework for Qualitative Reasoning . . . . .	7
2.2 The Design of VisiGarp . . . . .	9
2.2.1 Visual Primitives . . . . .	10
2.2.2 Visualization Principles . . . . .	12
2.3 The Different Views in VisiGarp . . . . .	15
2.3.1 The main window: opening a simulation . . . . .	17
2.3.2 The main window: the state-transition diagram . . . . .	18
2.3.3 The transition history view . . . . .	22
2.3.4 The transition details view . . . . .	22
2.3.5 The entities and relations view . . . . .	23
2.3.6 The entity is-a hierarchy view . . . . .	24
2.3.7 The dependencies view . . . . .	25
2.3.8 The quantity values view . . . . .	30
2.3.9 The quantity value history view . . . . .	31
2.3.10 The model fragments view . . . . .	32
2.3.11 The model fragment graphics view . . . . .	32
2.3.12 The model fragment text view . . . . .	33
2.3.13 The model fragment is-a hierarchy view . . . . .	33
2.3.14 The model fragment applies-to hierarchy view . . . . .	34
2.3.15 The scenarios view . . . . .	35
2.3.16 The transition rules view . . . . .	36
2.4 Using VisiGarp in an educational context . . . . .	37
2.5 Evaluation of VisiGarp . . . . .	38
2.5.1 Test Domain: The Ecology of the Brazilian Cerrado Vegetation . . . . .	39
2.5.2 Evaluation of VisiGarp 0.9: The Two Pilot Studies . . . . .	39
2.5.3 Evaluation of VisiGarp 1.0 by thirty first-year students . . . . .	42
2.5.4 VisiGarp in use at Universities . . . . .	55
2.6 Related Work on Visualization of Qualitative Models . . . . .	57
2.7 Conclusion . . . . .	58

<b>3</b>	<b>Aggregation of Qualitative Simulations</b>	<b>61</b>
3.1	Introduction	61
3.2	Review of the Literature on Aggregation	62
3.3	Levels of Aggregation	65
3.4	Aggregation methods	67
3.5	Aggregation techniques: applying the methods to the five levels	70
3.5.1	System State Level	70
3.5.2	Local Event Level	74
3.5.3	Path Segment Level	90
3.5.4	Path Level	90
3.5.5	Global Level	93
3.6	Numerical Results	99
3.7	Discussion	100
3.7.1	Further research	102
3.8	Conclusion	103
<b>4</b>	<b>Interactive Explanation</b>	<b>105</b>
4.1	Introduction	105
4.2	Review of the Literature on Explanation Generation	106
4.3	Conceptual Design of WiziGarp	108
4.3.1	Didactic Goals	109
4.3.2	Didactic Means of Communication	111
4.3.3	Didactic Styles	113
4.4	System Design of WiziGarp	113
4.4.1	Topic Selection	115
4.4.2	Determination of Relevant Information	120
4.4.3	Interactive Visualizations	120
4.4.4	Generation of Textual Descriptions	126
4.4.5	Generation of Contrastive Explanations	130
4.4.6	Query Generation and Selection	132
4.4.7	Generation of Causal Explanations	133
4.4.8	Question Generation	139
4.4.9	The Didactic Plan	147
4.5	Discussion	149
4.5.1	Didactic Goals Revisited	149
4.5.2	Didactic Means Revisited	150
4.5.3	Generic vs. Domain-specific	151
4.6	Conclusion	151

<b>5</b>	<b>Scenarios of Explanatory Interaction</b>	<b>153</b>
5.1	Introduction . . . . .	153
5.2	Scenario 1: System-initiated tutoring . . . . .	153
5.3	Scenario 2: Student-initiated exploration . . . . .	173
5.4	Discussion . . . . .	194
	5.4.1 Evaluation of WiziGarp . . . . .	194
	5.4.2 Didactic Planning . . . . .	194
	5.4.3 Collaborative Learning . . . . .	195
5.5	Conclusion . . . . .	196
<b>6</b>	<b>Conclusion</b>	<b>197</b>
6.1	Summary of the Main Results . . . . .	197
6.2	Visualization of Qualitative Simulations . . . . .	197
6.3	Aggregation of Qualitative Simulations . . . . .	199
6.4	Interactive Explanation . . . . .	199
6.5	Future Work . . . . .	201
6.6	Concluding Remarks . . . . .	202
<b>A</b>	<b>VisiGarp Treatment Exercise Questions</b>	<b>203</b>
	<b>List of Figures</b>	<b>213</b>
	<b>List of Tables</b>	<b>217</b>
	<b>Bibliography</b>	<b>219</b>
	<b>Summary</b>	<b>229</b>
	<b>Samenvatting</b>	<b>233</b>