Contents

INTRODUCTION ix

CHAPTER 1. BUILDING OBJECTS IN TIME 1

1.1. Different points of view on ontology 4
1.1.1. Defining ontology 4
1.1.2. Qualification of the objects from an ontological perspective: "bona fide" versus "fiat" objects 8
1.1.3. Specification of ontologies in the field of spatial analysis and geographical sciences: objects versus fields 10
1.1.4. An example of empirical objects' construction: the case of cities 13
1.2. Locating spatial objects in time 16
1.2.1. Objects' formalization in time: "endurant" and "perdurant" entities of philosophers 17
1.2.2. From change to objects' life 21
1.3. Conclusion 28

CHAPTER 2. FROM EMPIRICAL QUESTIONING TO SPATIO-TEMPORAL MODELING 29

2.1. From the conception of entities to their analysis of responding to thematic issues 30
2.1.1. Building the spatio-temporal objects from the empirical observations (challenge 1) 32
2.1.2. Representing and exploring change and movement (challenge 2) 35
2.1.3. Analyzing the evolution of statistical and spatial relationships (challenge 3) 38

2.1.4. Identifying the underlying processes of change: simulation and scenario testing (challenge 4) 41
2.2. Challenges and models: the possible misunderstandings 44
2.3. Application examples 46
2.3.1. Cities' dynamics: construction and follow-up of composite objects in time 47
2.3.2. Distribution of urban functions in the intra-urban space: construction of spatio-temporal functional objects 53
2.3.3. Evaluating the impact of mobile objects on a spatial support 56
2.3.4. What factors are behind the emergence and/or the reinforcement of school segregation? Construction of multilevel and multidate information 60
2.4. Conclusion 64

CHAPTER 3. ANALYZING SPATIO-TEMPORAL DATA: EMPIRICAL AND STATISTICAL APPROACHES 65

3.1. Statistical data and spatio-temporal analysis 66
3.1.1. Spatial analysis evolution in a context influenced by statistics and computer science 66
3.1.2. Different ways to take time and space into account to analyze spatio-temporal processes 70
3.1.3. From entities' dynamics to that of organizations: what is it that changes and relative to what frame of reference? 73
3.2. Following the evolution of the structure of spatial systems 76
3.2.1. Describing the evolution of space and hierarchical organizations 76
3.2.2. Change, temporalities and statistical explanations 82
3.3. Understanding the evolution of a spatial system's entities 86
3.3.1. Constructing, describing and categorizing trajectories of evolution 87
3.3.2. Identifying *a priori* defined types of change to classify evolutions 91
3.3.3. "Unfolded" time and forecast 93
3.4. Conclusion 97

Chapter 4. Exploring the Underlying Processes of Change: Simulation Models 99

4.1. Computer simulation *versus* statistical approach: different points of view about explanation 99
4.1.1. From covariation to interaction, from differentiation to emergence 102
4.1.2. Different types of explanation: from the percentage of variance explained to the generation of mechanisms 104
4.1.3. Different points of view on multilevel phenomena 105
4.2. Microsimulation models 107
4.3. Computing models: simulation and emergence. 112
4.3.1. Modeling the diffusion of a migratory wave front. 113
4.3.2. Cellular automata approaches: the case of land use changes. 115
4.3.3. Agent-based models applied to simple entities 120
4.3.4. Agent modeling on composite entities 124
4.4. Conclusion 129

CONCLUSION 133

BIBLIOGRAPHY 139

INDEX 155