
Contents

Preface to the Second Edition	vii
Preface to the First Edition	ix
Acknowledgements	xiii
Acronyms	xxiii
List of Figures	xxvii
List of Tables	xxxv
1 Introduction	1
1.1 What Is Computational Social Science?	1
1.2 A Computational Paradigm of Society	2
1.3 CSS as an Instrument-Enabled Science	3
1.4 Examples of CSS Investigations: Pure Scientific Research Versus Applied Policy Analysis	4
1.5 Society as a Complex Adaptive System	7
1.5.1 What Is a CAS in CSS?	7
1.5.2 Tripartite Ontology of Natural, Human, and Artificial Systems	9
1.5.3 Simon's Theory of Artifacts: Explaining Basic Social Complexity	10
1.5.4 Civilization, Complexity, and Quality of Life: Role of Artificial Systems	11
1.6 Main Areas of CSS: An Overview	12
1.6.1 Automated Social Information Extraction	13
1.6.2 Social Networks	14
1.6.3 Social Complexity	14
1.6.4 Social Simulation Modeling	15
1.7 A Brief History of CSS	18
1.8 Main Learning Objectives	20
Problems	21
Exercises	26
Recommended Readings	32

2	Computation and Social Science	35
2.1	Introduction and Motivation	35
2.2	History and First Pioneers	36
2.3	Computers and Programs	37
2.3.1	Structure and Functioning of a Computer	37
2.3.2	Compilers and Interpreters	40
2.4	Computer Languages	40
2.5	Operators, Statements, and Control Flow	45
2.6	Coding Style	47
2.7	Abstraction, Representation, and Notation	48
2.8	Objects, Classes, and Dynamics in Unified Modeling Language (UML)	53
2.8.1	Ontology	53
2.8.2	The Unified Modeling Language (UML)	57
2.8.3	Attributes	68
2.8.4	Operations	71
2.9	Data Structures	74
2.10	Modules and Modularization	76
2.11	Computability and Complexity	77
2.12	Algorithms	78
	Problems	80
	Exercises	93
	Recommended Readings	101
3	Automated Information Extraction	103
3.1	Introduction and Motivation	103
3.2	History and First Pioneers	104
3.3	Linguistics and Principles of Content Analysis: Semantics and Syntax	107
3.4	Semantic Dimensions of Meaning: From Osgood to Heise	109
3.4.1	EPA-Space and the Structure of Human Information Processing and Meaning	109
3.4.2	Cross-Cultural Universality of Meaning	111
3.5	Data Mining: Overview	112
3.6	Data Mining: Methodological Process	114
3.6.1	Research Questions	115
3.6.2	Source Data: Selection and Procurement	116
3.6.3	Preprocessing Preparations	116
3.6.4	Analysis	117
3.6.5	Communication	124
	Problems	124
	Exercises	133
	Recommended Readings	139

4	Social Networks	141
4.1	Introduction and Motivation	141
4.2	History and First Pioneers	142
4.3	Definition of a Network	147
4.3.1	A Social Network as a Class Object	148
4.3.2	Relational Types of Social Networks	149
4.3.3	Level of Analysis	150
4.3.4	Dynamic Networks	151
4.4	Elementary Social Network Structures	152
4.5	The Network Matrix	155
4.6	Quantitative Measures of a Social Network	155
4.6.1	Nodal Measures: Micro Level	156
4.6.2	Network Measures: Macro-Level	157
4.7	Dynamic (Actually, Kinetic) Networks as Ternary Associations	158
4.8	Applications	159
4.8.1	Human Cognition and Belief Systems	159
4.8.2	Decision-Making Models	163
4.8.3	Organizations and Meta-Models	163
4.8.4	Supply Chains	165
4.8.5	The Social Structure of Small Worlds	167
4.8.6	International Relations	167
4.9	Software for SNA	168
	Problems	170
	Exercises	182
	Recommended Readings	191
5	Social Complexity I: Origins and Measurement	193
5.1	Introduction and Motivation	193
5.2	History and First Pioneers	193
5.3	Origins and Evolution of Social Complexity	196
5.3.1	Sociogenesis: The “Big Four” Primary Polity Networks	197
5.3.2	Social Complexity Elsewhere: Secondary Polity Networks	201
5.3.3	Contemporary Social Complexity: Globalization	202
5.3.4	Future Social Complexity	203
5.4	Conceptual Foundations	205
5.4.1	What Is Social Complexity?	205
5.4.2	Defining Features of Social Complexity	206
5.5	Measurement of Social Complexity	209
5.5.1	Qualitative Indicators: Lines of Evidence	210
5.5.2	Quantitative Indicators	212

Problems	219
Exercises	234
Recommended Readings	245
6 Social Complexity II: Laws	247
6.1 Introduction and Motivation	247
6.2 History and First Pioneers	247
6.3 Laws of Social Complexity: Descriptions	249
6.3.1 Structural Laws: Serial, Parallel, and Hybrid Complexity	249
6.3.2 Distributional Laws: Scaling and Nonequilibrium Complexity	255
6.4 Power Law Analysis	264
6.4.1 Empirical Analysis: Estimation and Assessing Goodness of Fit	264
6.4.2 Theoretical Analysis: Deriving Implications	267
6.5 Universality in Laws of Social Complexity	272
Problems	272
Exercises	280
Recommended Readings	288
7 Social Complexity III: Theories	291
7.1 Introduction and Motivation	291
7.2 History and First Pioneers	291
7.3 Theories of Social Complexity: Elements of Explanation	294
7.3.1 Sequentiality: Modeling Processes. Forward Logic	295
7.3.2 Conditionality: Modeling Causes. Backward Logic	299
7.3.3 Hybrid Bimodal Social Complexity: Several-Among-Some Causes	303
7.4 Explaining Initial Social Complexity	304
7.4.1 Emergence of Chiefdoms	310
7.4.2 Emergence of States	319
7.5 General Theories of Social Complexity	328
7.5.1 Theory of Collective Action	328
7.5.2 Simon's Theory of Adaptation via Artifacts	331
7.5.3 Canonical Theory as a Unified Framework	335
Problems	341
Exercises	360
Recommended Readings	371
8 Simulations I: Methodology	375
8.1 Introduction and Motivation	375
8.2 History and First Pioneers	376

8.3	Purpose of Simulation: Investigating Social Complexity Via Virtual Worlds	377
8.4	Basic Simulation Terminology	379
8.5	Fidelity of Representation and Implications	382
8.6	Types of Social Simulation: From System Dynamics to Agent-Based Models	383
8.7	Development Methodology of Social Simulations	384
8.7.1	Motivation: What Are the Research Questions Addressed by a Given Model?	384
8.7.2	Conceptual Design: What Does the Abstraction Look Like?	386
8.7.3	Implementation: How Is the Abstracted Model Written in Code?	387
8.7.4	Verification: Does the Simulation Perform as Intended?	388
8.7.5	Validation: Can We Trust the Results?	389
8.7.6	Virtual Experiments and Scenario Analyses: What New Information Does the Simulation Generate?	390
8.8	Assessing the Quality of a Social Simulation	391
8.8.1	General Principles for Social Modeling Assessment	391
8.8.2	Dimensions of Quality in Social Simulation Models	393
8.9	Methodology of Complex Social Simulations	396
8.10	Comparing Simulations: How Are Computational Models Compared?	398
	Problems	400
	Exercises	408
	Recommended Readings	413
9	Simulations II: Variable-Oriented Models	415
9.1	Introduction and Motivation	415
9.2	History and First Pioneers	415
9.3	System Dynamics Models	417
9.3.1	Motivation: Research Questions	419
9.3.2	Design: Abstracting Conceptual and Formal Models	419
9.3.3	Implementation: System Dynamics Software	425
9.3.4	Verification	426
9.3.5	Validation	426
9.3.6	Analysis	427
9.4	Queueing Models	429
9.4.1	Motivation: Research Questions	429
9.4.2	Design: Abstracting Conceptual and Formal Models	432

9.4.3	Implementation: Queuing Systems Software	435
9.4.4	Verification	435
9.4.5	Validation	436
9.4.6	Analysis.	436
	Problems.	437
	Exercises.	445
	Recommended Readings	453
10	Simulations III: Object-Oriented Models.	455
10.1	Introduction and Motivation	455
10.2	History and First Pioneers	455
10.3	Cellular Automata Models	459
10.3.1	Motivation: Research Questions	463
10.3.2	Design: Abstracting Conceptual and Formal Models	463
10.3.3	Implementation: Cellular Automata Software	466
10.3.4	Verification	468
10.3.5	Validation	468
10.3.6	Analysis.	469
10.4	Agent-Based Models.	470
10.4.1	Motivation: Research Questions	473
10.4.2	Design: Abstracting Conceptual and Formal Models	476
10.4.3	Implementation: Agent-Based Simulation Systems	479
10.4.4	Verification	482
10.4.5	Validation	482
10.4.6	Analysis.	483
	Problems.	484
	Exercises.	496
	Recommended Readings	508
	Answers to Problems	513
	Glossary	543
	References	585
	Author Index.	593
	Subject Index.	601

<http://www.springer.com/978-3-319-50130-7>

Introduction to Computational Social Science
Principles and Applications

Cioffi-Revilla, C.

2017, XXXVI, 607 p. 59 illus., 21 illus. in color.,
Hardcover

ISBN: 978-3-319-50130-7