Cambridge University Press & Assessment 978-1-108-83476-6 — Complexity Science Henrik Jeldtoft Jensen Table of Contents <u>More Information</u>

## Contents

Acknowledgements			<i>page</i> xi
Ν	xiii		
Pr	eface		xvii
I	Conc	eptual Foundation of Complexity Science	1
In	3		
1	The S	Science of Emergence	5
	1.1	The Importance of Interaction	9
	1.2	Past Views on Emergence	15
	1.3	Further Reading	18
	1.4	Exercises and Projects	19
2	Conc	eptual Framework of Emergence	21
	2.1	Emergence of a Characteristic Scale or Lack of Scale	23
	2.2	Emergence of Collective Robust Degrees of Freedom	26
	2.3	Structural Coherence	28
	2.4	Evolutionary Diffusion	31
	2.5	Breaking of Symmetry	33
	2.6	Emergence of Networks	35
	2.7	Temporal Mode	37
	2.8	Adaptive and Evolutionary Dynamics	39
	2.9	Further Reading	40
	2.10	Exercises and Projects	41
3	3 Specific Types of Emergent Behaviour		46
	3.1	Ising-Type Models: Transitions and Criticality	48
	3.2	Network Models and Scale vs. No Scale	52
	3.3	Emergence of Coherence in Time: Synchronisation	57
	3.4	Evolutionary Dynamics: Adaptation	60
	3.5	Mean-Field Modelling: Dimensionality and Forecasting	64
	3.6	Further Reading	69
	3.7	Exercises and Projects	70

vii

Cambridge University Press & Assessment 978-1-108-83476-6 — Complexity Science Henrik Jeldtoft Jensen Table of Contents <u>More Information</u>

4	The	Value of Prototypical Models of Emergence	75
	4.1	The Need for Simplification of Models	76
	4.2	O'Keeffe–Einstein Propositions at Work	78
	4.3	Further Reading	82
	4.4	Exercises and Projects	83
П	Mat	thematical Tools of Complexity Science	87
Int	trodu	ction to Part II	89
5	Bran	iching Processes	93
	5.1	Generator Functions: Sizes and Lifetimes	97
		5.1.1 Size of the Progeny	99
		5.1.2 Time to Extinction	102
	5.2	Branching Trees and Random Walks	103
	5.3	Further Reading	106
	5.4	Exercises and Projects	107
6	Stat	istical Mechanics	110
	6.1	Probabilities and Ensembles	110
	6.2	The Ising Model	119
	6.3	The Peculiar Nature of the Critical Point	125
	6.4	Fluctuations, Response and Correlations	127
	6.5	Examples of Correlation Functions: Brain, Flocks of Birds, Finance	132
	6.6	Diverging Range of Correlations	133
		6.6.1 Correlation Function – Exact Approach	134
		6.6.2 Correlation Function – Intuitive Discussion	139
	6.7	The Two-Dimensional XY Model	143
		6.7.1 2d XY: Some Mathematical Details	148
		6.7.2 Vortex Unbinding	153
		6.7.3 The Vortex Unbinding Transition in Other Systems	154
	6.8	Further Reading	156
	6.9	Exercises and Projects	156
7	Sync	hronisation	163
	7.1	The Kuramoto Model: The Onset of Synchronisation	164
	7.2	Chimera States	170
	7.3	Further Reading	174
	7.4	Exercises and Projects	175
8	Netv	vork Theory	177
	8.1	Basic Concepts	178
	8.2	Measures of the Importance of Nodes	179

CAMBRIDGE

Cambridge University Press & Assessment 978-1-108-83476-6 — Complexity Science Henrik Jeldtoft Jensen Table of Contents <u>More Information</u>

		Contents	іх
		8.2.1 Degree Centrality	179
		8.2.2 Eigenvector Centrality	184
		8.2.3 Closeness Centrality	187
		8.2.4 Betweenness Centrality	187
		8.2.5 How Well Does it Work?	188
	8.3	Community Detection	188
	8.4	Spreading on Networks – Giant Cluster	196
	8.5	Analysis of Dynamics of and on Networks	203
		8.5.1 Generating Networks	204
		8.5.2 Random Walk on Networks	212
		8.5.3 Synchronisation on Networks	216
	8.6	Further Reading	224
	8.7	Exercises and Projects	225
9	Infor	mation Theory and Entropy	230
	9.1	Information Theory and Interdependence	232
	9.2	Entropy and Estimates of Causal Relations	237
	9.3	From Time Series to Networks	241
	9.4	From Entropy to Probability Distribution	245
	9.5	Measures of Degrees of Complexity	256
		9.5.1 Lempel–Ziv Complexity Measure	256
		9.5.2 Information-Theoretic Approach to Emergence	259
		9.5.3 Group Entropy Measure of Complexity	272
	9.6	Further Reading	274
	9.7	Exercises and Projects	275
10	Stock	nastic Dynamics and Equations for the Probabilities	279
	10.1	Random Walk and Diffusion	280
	10.2	First Passage and First Return Times	293
	10.3	Correlations in Time	297
	10.4	Random Walk with Persistence or Anti-persistence: Hurst Exponent	302
	10.5	Stationary Diffusion: Ornstein–Uhlenbeck Process	307
	10.6	Evolutionary Dynamics and Clustering	309
	10.7	Master Equation, Coarse Graining and Free Energy	313
	10.8	Further Reading	318
	10.9	Exercises and Projects	319
11	مەم	t-Based Modelling	374
	11 1	Flocks of Birds or Schools of Fish	324
	11.1	Models of Segregation	325
	11.2	The Tangled Nature Model	337
	11.5	Further Reading	349
	11.5	Exercises and Projects	350
			220

Cambridge University Press & Assessment 978-1-108-83476-6 — Complexity Science Henrik Jeldtoft Jensen Table of Contents <u>More Information</u>

## x Contents

12 Intermittency			
12.1 Self-Organised Criticality	357		
12.1.1 Sandpile Models	358		
12.1.2 Mean-Field Analysis	361		
12.1.3 Lessons from Sandpile Models	364		
12.1.4 Forest Fire Model	367		
12.2 Record Dynamics	370		
12.2.1 Statistics of Records	371		
12.2.2 Spin Glasses, Superconductors, Ants and Evolution	375		
12.3 Tangent Map Intermittency	379		
12.4 Further Reading	382		
12.5 Exercises and Projects	383		
13 Tipping Points, Transitions and Forecasting			
13.1 Externally Induced Transitions	387		
13.2 Intrinsic Instability	389		
13.3 Further Reading	395		
13.4 Exercises and Projects	395		
14 Concluding Comments and a Look to the Future	397		
14.1 Further Reading	399		
Glossary	401		
References			
Index			