

Contents

1	Introduction	1
1.1	What Is Data Analysis?	1
1.2	Objectives of the Book	5
1.3	Outline of the Book	6
1.3.1	Data	6
1.3.2	Tasks	8
1.3.3	Tools	10
1.3.4	General Principles	14
	References	16
2	Data.....	17
	Abstract.....	17
2.1	Structure of Data	18
2.1.1	Functional View of Data Structure	21
2.1.2	Other Approaches	25
2.2	Properties of Data.....	27
2.2.1	Other Approaches	31
2.3	Examples of Data	34
2.3.1	Portuguese Census	34
2.3.2	Forests in Europe	36
2.3.3	Earthquakes in Turkey	36
2.3.4	Migration of White Storks	38
2.3.5	Weather in Germany	40
2.3.6	Crime in the USA.....	41
2.3.7	Forest Management Scenarios	42
	Summary.....	44
	References	45
3	Tasks	47
	Abstract.....	47
3.1	Jacques Bertin's View of Tasks	49
3.2	General View of a Task.....	53

3.3	Elementary Tasks	60
3.3.1	Lookup and Comparison	61
3.3.2	Relation-Seeking	69
3.3.3	Recap: Elementary Tasks	75
3.4	Synoptic Tasks	81
3.4.1	General Notes	81
3.4.2	Behaviour and Pattern	83
3.4.3	Types of Patterns	91
3.4.3.1	Association Patterns	91
3.4.3.2	Differentiation Patterns	93
3.4.3.3	Arrangement Patterns	94
3.4.3.4	Distribution Summary	95
3.4.3.5	General Notes	96
3.4.4	Behaviours over Multidimensional Reference Sets	98
3.4.5	Pattern Search and Comparison	107
3.4.6	Inverse Comparison	112
3.4.7	Relation-Seeking	115
3.4.8	Recap: Synoptic Tasks	119
3.5	Connection Discovery	124
3.5.1	General Notes	124
3.5.2	Properties and Formalisation	127
3.5.3	Relation to the Former Categories	134
3.6	Completeness of the Framework	139
3.7	Relating Behaviours: a Cognitive-Psychology Perspective	143
3.8	Why Tasks?	148
3.9	Other Approaches	151
	Summary	158
	References	159
4	Tools	163
	Abstract	163
4.1	A Few Introductory Notes	165
4.2	The Value of Visualisation	166
4.3	Visualisation in a Nutshell	171
4.3.1	Bertin's Theory and Its Extensions	171
4.3.2	Dimensions and Variables of Visualisation	182
4.3.3	Basic Principles of Visualisation	189
4.3.4	Example Visualisations	196
4.4	Display Manipulation	207
4.4.1	Ordering	207
4.4.2	Eliminating Excessive Detail	214
4.4.3	Classification	217

4.4.4	Zooming and Focusing	231
4.4.5	Substitution of the Encoding Function	241
4.4.6	Visual Comparison	248
4.4.7	Recap: Display Manipulation	257
4.5	Data Manipulation	259
4.5.1	Attribute Transformation	261
4.5.1.1	"Relativisation"	261
4.5.1.2	Computing Changes	263
4.5.1.3	Accumulation	268
4.5.1.4	Neighbourhood-Based Attribute Transformations	269
4.5.2	Attribute Integration	276
4.5.2.1	An Example of Integration	278
4.5.2.2	Dynamic Integration of Attributes	279
4.5.3	Value Interpolation	288
4.5.4	Data Aggregation	293
4.5.4.1	Grouping Methods	294
4.5.4.2	Characterising Aggregates	297
4.5.4.3	Visualisation of Aggregate Sizes	300
4.5.4.4	Sizes Are Not Only Counts	312
4.5.4.5	Visualisation and Use of Positional Measures	316
4.5.4.6	Spatial Aggregation and Reaggregation	327
4.5.4.7	A Few Words About OLAP	332
4.5.4.8	Data Aggregation: a Few Concluding Remarks	333
4.5.5	Recap: Data Manipulation	335
4.6	Querying	336
4.6.1	Asking Questions	337
4.6.1.1	Spatial Queries	341
4.6.1.2	Temporal Queries	346
4.6.1.3	Asking Questions: Summary	349
4.6.2	Answering Questions	351
4.6.2.1	Filtering	353
4.6.2.2	Marking	363
4.6.2.3	Marking Versus Filtering	371
4.6.2.4	Relations as Query Results	373
4.6.3	Non-Elementary Queries	381
4.6.4	Recap: Querying	393
4.7	Computational Tools	395
4.7.1	A Few Words About Statistical Analysis	397
4.7.2	A Few Words About Data Mining	401
4.7.3	The General Paradigm for Using Computational Tools	406
4.7.4	Example: Clustering	407
4.7.5	Example: Classification	415

4.7.6	Example: Data Preparation	423
4.7.7	Recap: Computational Tools.....	425
4.8	Tool Combination and Coordination.....	428
4.8.1	Sequential Tool Combination	429
4.8.2	Concurrent Tool Combination	434
4.8.3	Recap: Tool Combination	447
4.9	Exploratory Tools and Technological Progress	450
	Summary.....	453
	References	454
5	Principles.....	461
	Abstract.....	461
5.1	Motivation.....	463
5.2	Components of the Exploratory Process	465
5.3	Some Examples of Exploration.....	467
5.4	General Principles of Selection of the Methods and Tools	480
5.4.1	Principle 1: See the Whole.....	481
5.4.1.1	Completeness.....	483
5.4.1.2	Unification	494
5.4.2	Principle 2: Simplify and Abstract.....	506
5.4.3	Principle 3: Divide and Group	509
5.4.4	Principle 4: See in Relation.....	518
5.4.5	Principle 5: Look for Recognisable	530
5.4.6	Principle 6: Zoom and Focus	540
5.4.7	Principle 7: Attend to Particulars	544
5.4.8	Principle 8: Establish Linkages.....	552
5.4.9	Principle 9: Establish Structure.....	572
5.4.10	Principle 10: Involve Domain Knowledge	579
5.5	General Scheme of Data Exploration: Tasks, Principles, and Tools	584
5.5.1	Case 1: Single Referrer, Holistic View Possible.....	587
5.5.1.1	Subcase 1.1: a Homogeneous Behaviour.....	588
5.5.1.2	Subcase 1.2: a Heterogeneous Behaviour.....	590
5.5.2	Case 2: Multiple Referrers	593
5.5.2.1	Subcase 2.1: Holistic View Possible.....	595
5.5.2.2	Subcase 2.2: Behaviour Explored by Slices and Aspects.....	598
5.5.3	Case 3: Multiple Attributes	602
5.5.4	Case 4: Large Data Volume	606
5.5.5	Final Remarks	611
5.6	Applying the Scheme (an Example).....	613
	Summary.....	630

References	632
6 Conclusion.....	635
Appendix I: Major Definitions	639
I.1 Data	639
I.2 Tasks	643
I.3 Tools.....	647
Appendix II: A Guide to Our Major Publications Relevant to This Book	651
References	653
Appendix III: Tools for Visual Analysis of Spatio-Temporal Data Developed at the AIS Fraunhofer Institute	657
References	658
Index.....	659