Statistics and Computing

Leland Wilkinson

The Grammar of Graphics

Second Edition

Springer

Contents

Preface **ix**

1 Introduction **1**
1.1 Graphics Versus Charts 2
1.2 Object-Oriented Design 3
1.3 An Object-Oriented Graphics System 6
1.4 An Example 8
1.5 What This Book Is Not 13
1.6 Background 18
1.7 Sequel 18

Part I **21**

2 How To Make a Pie **23**
2.1 Definitions 25
2.2 Recipe 31
2.3 Notation 38
2.4 Sequel 40

3 Data **41**
3.1 Data Functions 42
3.2 Empirical Data 44
3.3 Abstract Data 48
3.4 Metadata 51
3.5 Data Mining 51
3.6 Sequel 54

4 Variables **55**
4.1 Transforms 56
4.2 Examples 57
4.3 Sequel 61

5 Algebra 63
5.1 Syntax 63
5.2 Examples 73
5.3 Other Algebras 80
5.4 Sequel 83

6 Scales 85
6.1 Scaling Theory 85
6.2 Scale Transformations 93
6.3 Sequel 109

7 Statistics 111
7.1 Methods 113
7.2 Examples 123
7.3 Summary 152
7.4 Sequel 154

8 Geometry 155
8.1 Examples 158
8.2 Summary 177
8.3 Sequel 178

9 Coordinates 179
9.1 Transformations of the Plane 180
9.2 Projections onto the Plane 227
9.3 3D Coordinate Systems 244
9.4 High-Dimensional Spaces 248
9.5 Tools and Coordinates 253
9.6 Sequel 254

10 Aesthetics 255
10.1 Continuous Scales 256
10.2 Categorical Scales 261
10.3 Dimensions 265
10.4 Realism 270
10.5 Aesthetic Attributes 274
10.6 Examples 293
10.7 Summary 316
10.8 Sequel 318

11 Facets **319**
11.1 Facet Specification 319
11.2 Algebra of Facets 320
11.3 Examples 327
11.4 Sequel 345

12 Guides **347**
12.1 Scale Guides 348
12.2 Annotation Guides 352
12.3 Sequel 356

Part 2 **357**

13 Space **359**
13.1 Mathematical Space 363
13.2 Psychological Space 378
13.3 Graphing Space 381
13.4 Sequel 405

14 Time **407**
14.1 Mathematics of Time 408
14.2 Psychology of Time 424
14.3 Graphing Time 427
14.4 Sequel 449

15 Uncertainty **451**
15.1 Mathematics of Uncertainty 451
15.2 Psychology of Uncertainty 466
15.3 Graphing Uncertainty 468
15.4 Sequel 488

16 Analysis **489**
16.1 Variance Analysis 490
16.2 Shape Analysis 496
16.3 Graph Drawing. 500
16.4 Sequence Analysis 505
16.5 Pattern Analysis 517
16.6 Sequel 533

17 Control **535**
17.1 Building 535
17.2 Exploring 552
17.3 Sequel 577

18 Automation **579**
18.1 Graphics Production Language 580
18.2 Visualization Markup Language 589
18.3 Summary 608
18.4 Sequel 609

19 Reader **611**
19.1 The Problem 612
19.2 A Psychological Reader Model 614
19.3 A Graphics Grammar Reader Model 617
19.4 Research 622
19.5 Sequel 622

20 Coda **623**
20.1 Napoleon's March 623
20.2 Monarch Butterfly Migration 629
20.3 Conclusion 632
20.4 Sequel 634

References **635**

Author Index **673**

Subject Index **681**