

CONTENTS

Applications of Data Analysis

Scientific Data Analysis, 2

Aims of Data Analysis, 3

Modeling and Data Interpretation, 5

The Role of the Computer, 7

PART I. BASIC DATA ANALYSIS USING A COMPUTER

2. Initial Steps in Computer Data Analysis 13

Principles of Computer Data Processing, 13

1. Hardware, 14

a. The Central Processing Unit (CPU), 14

b. Input/Output Devices, 15

c. Data Storage, 16

2. Software, 17

3. Firmware, 19

4. Interfaces, 19

5. Machine “Intelligence”, 20

6. Data Flow Through a Computer System, 21

7. Distributed Processing, 21

× CONTENTS

Preparing Data for Computer Analysis, 22	
1. Strategies for Preparing Computer Data Files, 23	
2. Procedures for Loading Data into Computer Files, 24	
3. Merging Different Sets of Data, 24	
4. Error Checking, 25	
5. Databases, 26	
3. Basic Statistical Analysis	27
Basic Statistical Measures, 28	
Frequency Distributions, 29	
Graphical Displays, 29	
1. The Histogram, 29	
2. Effective Use of Histograms, 31	
3. The Cumulative Frequency Plot, 35	
The Normal Distribution, 39	
1. Statistical Decisions, 40	
2. Probability Graphs, 41	
3. Multiple Populations, 43	
4. Non-parametric Statistics, 45	
4. Multivariate Data Analysis	47
The Nature of Multivariate Data, 47	
1. Numeric and Descriptive Data, 48	
2. Analysis of Descriptive Data, 48	
The Two-Dimensional Case, 49	
1. Curve Fitting and Correlation, 49	
2. The Two-Dimensional Scatter Plot, 51	
3. Applications of Scatter Plots and Correlation Coefficients, 54	
4. Single-Valued Data, 57	
The N-Dimensional Case, 58	
5. Effective Use of Computerized Analysis Systems	60
Principles for Designing Analysis Programs, 61	
1. Parameter Specification, 61	
2. Interactive Definition of Parameters, 63	
3. Independence from Data Type, 65	

- 4. Effective Forms for Computer Output, 67
- Combining Programs: Effective Analysis Systems, 68
- Utility Operations to Support Data Analysis, 69
 - 1. Data Selection, 69
 - 2. Sorting, 75
 - 3. Printed Lists of Data Files, 77
- Operational Procedures, 78
 - 1. Naming Conventions, 78
 - 2. Use of Standard "Run-Streams", 79
 - 3. Documentation, 79
 - 4. Other Useful Practices, 80

PART II. ANALYSIS OF SPATIAL DATA WITH COMPUTER GRAPHICS

- 6. Fundamentals of Computer Plotting 85
 - Components of a Plotting System, 86
 - 1. Plotters, 86
 - 2. Graphical Displays on a Computer Terminal, 90
 - 3. Plotting Software, 92
 - 4. Digitizers, 94
 - Coordinate Systems, 95
 - 1. Position on the Earth's Surface: The UTM System, 96
 - 2. Coordinate Transformations, 98
 - 3. Coordinate Systems Used in Plotting, 101
 - Types of Computer Plots, 102
 - 1. Line Maps, 102
 - 2. Posted Maps, 102
 - 3. Contour Maps, 103
 - 4. Choropleth Maps, 105
 - 5. Profile Maps, 107
 - 6. Scatter Plots, 108
 - 7. Histograms, 108
 - 8. Three-Dimensional Views, 109
 - 9. Multivariate Displays, 110
 - 10. Computer Animation, 110

7	Effective Use of Computer Plotting	
	Organization of Plotting Programs, 111	
	1. Input of Data and Parameters, 112	
	2. Standard Plotting Functions, 113	
	3. Output of Plotted Data, 113	
	Plotting Requirements for Data Analysis, 114	
	Common Problems in Plotting Data, 116	
	1. Data Availability, 116	
	2. Contour Maps and Grid Interpolation, 117	
	3. Variable Data Density, 121	
	4. Line-Oriented Data, 124	
8.	Computer Plots as Aids to Data Analysis	127
	Posted Location Maps, 127	
	Determination of "Structure" in the Data, 132	
	1. Display Methods, 133	
	2. Separating Structural Components from the Complete Data, 136	
	a. Smoothing the Data, 137	
	b. Trend Surface Analysis, 145	
	c. Spatial Frequency Filtering, 150	
	3. One-Dimensional Data Displays, 150	
	Detection of Anomalies, 157	
	1. Anomalies Defined as Departures from Regional Structure, 157	
	2. Other Methods for Defining Anomalies, 158	
	3. Procedures for Data Display, 159	
9.	Enhanced Display Techniques	168
	Computer Plotting and Drafting, 168	
	Improvements to a Basic Computer Plot, 170	
	1. Coordinate Reference Points, 170	
	2. Titles and Associated Information, 172	
	High-Level Graphic Enhancements, 175	
	1. Physical and Cultural Display, 175	
	2. Prevention of Overposting, 177	

3. Using a CAD System with Other Computer Graphics, 179

PART III. INTRODUCTION TO ADVANCED ANALYSIS METHODS

10. Advanced Statistical Techniques

Geostatistics, 185

1. Applications of Geostatistics, 186
2. Regionalized Variables and the Variogram, 187
 - a. The Variogram, 187
 - b. Experimental and Model Variograms, 188
 - c. Anisotropic Data, 190
3. Estimation Using a Variogram Model, 191
 - a. Global Averages, 191
 - b. Kriging, 191
4. Applications of Computer Graphics, 193

Multivariate Data Analysis, 195

1. Multiple regression, 195
2. Principle Components and Factor Analysis, 196
3. Classification Methods, 196

Multivariate Data Display, 197

1. Direct Plotting of Two or Three Variables, 197
2. Symbolic Coding, 199
3. Use of Special Figures, 199
4. Displays that Support Multivariate Analysis, 201

Procedures for Array-Oriented Data

Time-Series Analysis, 204

1. Recording Time-Series Data, 206
2. Structural Analysis of Time Series, 208
3. Prediction, 209
4. Frequency Analysis, 210
5. The Frequency Spectrum, 212
6. Other Procedures, 213
7. Multiple Time Series, 214

8.	Use of Computer Graphics, 216	
	Image Processing, 219	
1.	Remote Sensing from Satellites, 221	
2.	Basic Computer Manipulation of Satellite Images, 222	
3.	Computer Analysis of Images, 223	
	Special Systems for Handling Large Arrays, 224	
1.	Examples of Large-Volume Data Sets, 225	
2.	Scalar and Vector Processors, 225	
3.	Array processors, 226	
4.	Supercomputers, 227	
12.	Physical Models and Data Interpretation	228
	The Nature of Mathematical Models, 229	
1.	Physical Models, 229	
2.	Empirical and Theoretical Models, 230	
	The Modeling Process, 231	
1.	The "Direct" Problem, 232	
2.	The "Inverse" Problem, 233	
3.	The Problem of Non-Uniqueness, 234	
	Predictive Modeling, 235	
	Examples of Modeling, 236	
1.	Geophysical Exploration with Gravity, 236	
2.	Economic Forecasting, 239	
3.	Reservoir Simulation, 240	
4.	Atmospheric Modeling, 242	
5.	Modeling of Dynamic Structures, 244	
	Conclusion, 245	
	Appendix A. Characteristics of Effective Analysis Systems. A Summary, 247	
	Appendix B. An Example Computer System for Data Analysis and Display, 249	
1.	Data Structure, 249	
2.	Data Management Programs, 250	
3.	Data Analysis: Statistics, 251	
4.	Data Analysis: Graphical Display, 252	

5. Use of the Complete System, 253	
6. Training, 253	
References	254
Glossary	261
Index	267