Statistics and Computing

John M. Chambers

Software for Data Analysis

Programming with R



Contents

1	Introduction: Principles and Concepts			
	1.1	Exploration: The Mission	1	
	1.2	Trustworthy Software: The Prime Directive	3	
	1.3	Concepts for Programming with R	4	
	1.4	The R System and the S Language	9	
2	Using R 1			
	2.1	Starting R	11	
	2.2	An Interactive Session	13	
	2.3	The Language	19	
	2.4	Objects and Names	24	
	2.5	Functions and Packages	25	
	2.6	Getting R	29	
	2.7	Online Information About R	31	
	2.8	What's Hard About Using R?	34	
3	Pro	gramming with R: The Basics	37	
	3.1	From Commands to Functions	37	
	3.2	Functions and Functional Programming	43	
	3.3	Function Objects and Function Calls	50	
	3.4	The Language	58	
	3.5	Debugging	61	
	3.6	Interactive Tracing and Editing	67	
	3.7	Conditions: Errors and Warnings	74	
	3.8	Testing R Software	76	
4	R Packages			
	4.1	Introduction: Why Write a Package?	79	
	4.2	The Package Concept and Tools	80	

xii CONTENTS

	4.3	Creating a Package			
	4.4	Documentation for Packages			
	4.5	Testing Packages			
	4.6	Package Namespaces			
	4.7	Including C Software in Packages			
	4.8	Interfaces to Other Software			
5	Obj	ects 111			
	5.1	Objects, Names, and References			
	5.2	Replacement Expressions			
	5.3	Environments			
	5.4	Non-local Assignments; Closures			
	5.5	Connections			
	5.6	Reading and Writing Objects and Data			
6	Basi	ic Data and Computations 139			
	6.1	The Evolution of Data in the S Language			
	6.2	Object Types			
	6.3	Vectors and Vector Structures			
	6.4	Vectorizing Computations			
	6.5	Statistical Data: Data Frames			
	6.6	Operators: Arithmetic, Comparison, Logic			
	6.7	Computations on Numeric Data			
	6.8	Matrices and Matrix Computations			
	6.9	Fitting Statistical models			
	6.10	Programming Random Simulations			
7	Data Visualization and Graphics 237				
	7.1	Using Graphics in R			
	7.2	The x-y Plot			
	7.3	The Common Graphics Model			
	7.4	The graphics Package			
	7.5	The grid Package			
	7.6	Trellis Graphics and the lattice Package 280			
8	Computing with Text 289				
	8.1	Text Computations for Data Analysis			
	8.2	Importing Text Data			
	8.3	Regular Expressions			
	8.4	Text Computations in R			

CONTERNITO	•••
CONTENTS	X111
COTTENTS	2011

	8.5	Using and Writing Perl				
	8.6	Examples of Text Computations				
9	New Classes 331					
9	9.1	Classes 331 Introduction: Why Classes?				
	9.1	•				
	9.2	Programming with New Classes				
		Inheritance and Inter-class Relations				
	9.4	Virtual Classes				
	9.5	Creating and Validating Objects				
	9.6	Programming with S3 Classes				
	9.7	Example: Binary Trees				
	9.8	Example: Data Frames				
10	Me	thods and Generic Functions 381				
	10.1	Introduction: Why Methods?				
	10.2	Method Definitions				
	10.3	New Methods for Old Functions				
	10.4	Programming Techniques for Methods				
		Generic Functions				
	10.6	How Method Selection Works				
11	Into	rfaces I: C and Fortran 411				
		Interfaces to C and Fortran				
		Calling R-Independent Subroutines				
		Calling R-Dependent Subroutines				
		Computations in C_{++}				
	11.5	Loading and Registering Compiled Routines 426				
12	Inte	erfaces II: Other Systems 429				
	12.1	Choosing an Interface				
	12.2	Text- and File-Based Interfaces				
	12.3	Functional Interfaces				
	12.4	Object-Based Interfaces				
		Interfaces to OOP Languages				
		Interfaces to C++				
		Interfaces to Databases and Spreadsheets				
	12.8	Interfaces without R				

xiv	CONTENTS

13	How R Works	453
	13.1 The R Program	. 453
	13.2 The R Evaluator	. 454
	13.3 Calls to R Functions	. 460
	13.4 Calls to Primitive Functions	. 463
	13.5 Assignments and Replacements	. 465
	13.6 The Language	. 468
	13.7 Memory Management for R Objects	. 471
A	Some Notes on the History of S	475
Bi	bliography	479
Inc	dex	481
Inc	dex of R Functions and Documentation	489
Inc	dex of R Classes and Types	497