

Table of Contents

Part I: Programming environments for motion, graphics, and geometry	7
1. Reducing a task to given primitives: programming motion	9
A robot car, its capabilities, and the task to be performed.....	9
Wall-following algorithm described informally.....	10
Algorithm specified in a high-level language.....	11
Algorithm programmed in the robot's language.....	12
The robot's program optimized.....	12
2. Graphics primitives and environments	14
Turtle graphics: a basic environment.....	14
QuickDraw: a graphics toolbox.....	16
A graphics frame program.....	19
3. Algorithm animation	24
Computer-driven visualization: characteristics and techniques.....	24
A gallery of algorithm snapshots.....	27
Part II: Programming concepts: beyond notation	33
4. Algorithms and programs as literature: substance and form	34
Programming in the large versus programming in the small.....	34
Documentation versus literature: is it meant to be read?.....	35
Pascal and its dialects: lingua franca of computer science.....	40
5. Divide-and-conquer and recursion	45
An algorithmic principle.....	45
Divide-and-conquer expressed as a diagram: merge sort.....	46
Recursively defined trees.....	47
Recursive tree traversal.....	49
Recursion versus iteration: the Tower of Hanoi.....	50
The flag of Alfanumerica: an algorithmic novel on iteration and recursion.....	52
6. Syntax	53
Syntax and semantics.....	53
Grammars and their representation: syntax diagrams and EBNF.....	54
An overly simple syntax for simple expressions.....	57
Parenthesis-free notation for arithmetic expressions.....	59
7. Syntax analysis	62
The role of syntax analysis.....	62
Syntax analysis of parenthesis-free expressions by counting.....	63
Analysis by recursive descent.....	64
Turning syntax diagrams into a parser.....	65
Part III: Objects, algorithms, programs	67
8. Truth values, the data type 'set', and bit acrobatics	69
Bits and boolean functions.....	69
Swapping and crossovers: the versatile exclusive-or.....	70
The bit sum or "population count".....	71
9. Ordered sets	78
Sequential search.....	78
Binary search.....	79
In-place permutation.....	82
10. Strings	87
Recognizing a pattern consisting of a single string.....	87
Recognizing a set of strings: a finite-state-machine interpreter.....	88
11. Matrices and graphs: transitive closure	93

Paths in a graph	93
Boolean matrix multiplication	94
Warshall's algorithm	95
Minimum spanning tree in a graph	97
12. Integers	100
Operations on integers	100
The Euclidean algorithm	102
The prime number sieve of Eratosthenes	103
Large integers	104
Modular number systems: the poor man's large integers	105
Random numbers	107
13. Reals	110
Floating-point numbers	110
Some dangers	112
Horner's method	113
Bisection	114
Newton's method for computing the square root	115
14. Straight lines and circles	119
Intersection	119
Clipping	122
Drawing digitized lines	123
The riddle of the braiding straight lines	126
Digitized circles	131
Part IV: Complexity of problems and algorithms	134
15. Computability and complexity	135
Models of computation: the ultimate RISC	135
Almost nothing is computable	138
The halting problem is undecidable	139
Computable, yet unknown	140
Multiplication of complex numbers	142
Complexity of matrix multiplication	142
16. The mathematics of algorithm analysis	146
Growth rates and orders of magnitude	146
Asymptotics	147
Summation formulas	148
Recurrence relations	150
Asymptotic performance of divide-and-conquer algorithms	153
Permutations	154
Trees	155
17. Sorting and its complexity	158
What is sorting? How difficult is it?	158
Types of sorting algorithms	160
Simple sorting algorithms that work in time $\Theta(n^2)$	163
A lower bound $\Omega(n \cdot \log n)$	165
Quicksort	166
Analysis for three cases: best, "typical", and worst	169
Is it possible to sort in linear time?	174
Sorting networks	174
Part V: Data structures	179
18. What is a data structure?	180
Data structures old and new	180

<u>The range of data structures studied</u>	181
<u>Performance criteria and measures</u>	182
19. Abstract data types	184
<u>Concepts: What and why?</u>	184
<u>Stack</u>	185
<u>First-in-first-out queue</u>	189
<u>Priority queue</u>	190
<u>Dictionary</u>	191
20. Implicit data structures	196
<u>What is an implicit data structure?</u>	196
<u>Array storage</u>	197
<u>Implementation of the fixed-length fifo queue as a circular buffer</u>	202
<u>Implementation of the fixed-length priority queue as a heap</u>	205
<u>Heapsort</u>	209
21. List structures	211
<u>Lists, memory management, pointer variables</u>	211
<u>The fifo queue implemented as a one-way list</u>	214
<u>Tree traversal</u>	214
<u>Binary search trees</u>	223
<u>Height-balanced trees</u>	228
22. Address computation	239
<u>Concepts and terminology</u>	239
<u>The special case of small key domains</u>	240
<u>The special case of perfect hashing: table contents known a priori</u>	241
<u>Conventional hash tables: collision resolution</u>	242
<u>Choice of hash function: randomization</u>	246
<u>Performance analysis</u>	248
<u>Extendible hashing</u>	249
<u>A virtual radix tree: order-preserving extendible hashing</u>	251
23. Metric data structures	254
<u>Organizing the embedding space versus organizing its contents</u>	254
<u>Radix trees, tries</u>	255
<u>Quadtrees and octrees</u>	255
<u>Spatial data structures: objectives and constraints</u>	257
<u>The grid file</u>	259
<u>Simple geometric objects and their parameter spaces</u>	263
<u>Region queries of arbitrary shape</u>	264
<u>Evaluating region queries with a grid file</u>	267
<u>Interaction between query processing and data access</u>	267
Part VI: Interaction between algorithms and data structures: case studies in geometric computation	271
24. Sample problems and algorithms	272
<u>Geometry and geometric computation</u>	272
<u>Convex hull: a multitude of algorithms</u>	273
<u>The uses of convexity: basic operations on polygons</u>	277
<u>Visibility in the plane: a simple algorithm whose analysis is not</u>	279
25. Plane-sweep: a general-purpose algorithm for two-dimensional problems illustrated using line segment intersection	286
<u>The line segment intersection test</u>	286
<u>The skeleton: Turning a space dimension into a time dimension</u>	288
<u>Data structures</u>	288

This book is licensed under a [Creative Commons Attribution 3.0 License](#)

Updating the y-table and detecting an intersection	289
Sweeping across intersections	290
Degenerate configurations, numerical errors, robustness	291
26. The closest pair	293
The problem	293
Plane-sweep applied to the closest pair problem	294
Implementation	295
Analysis	297
Sweeping in three or more dimensions	298