
Contents

1	Introduction	1
1.1	What Is Software Visualization?	3
1.2	Organization of This Book	4
1.3	Software Visualization and Visual Programming	6
1.4	Examples of Software Visualization Tools	7
1.4.1	StackAnalyzer: Static Program Visualization	7
1.4.2	X-Tango: Algorithm Animation	8
1.4.3	SecSoft: Software Evolution	9
1.5	Taxonomies and Surveys	9
1.6	The Visualization Pipeline	12
	Exercises	13
2	Visualization Basics	15
2.1	Perception and Cognition	15
2.1.1	Visual Memory	16
2.1.2	The Human Eye	16
2.1.3	Light, Color, and Color Perception	17
2.1.4	Pattern Perception	17
2.1.5	Preattentive Perception	18
2.1.6	Motion Perception	19
2.1.7	Implications for the Design of Visualizations	20
2.2	Graphical Representation	21
2.2.1	Graphical Primitives and Properties	21
2.2.2	Text	22
2.2.3	Diagrams	22
2.2.4	3D Graphics and Rendering	22
2.3	General Information Visualization Techniques	25
2.3.1	Visualization of Textual Data	25
2.3.2	Graph Drawing	26

2.3.3	Visualization of Hierarchies	29
2.4	Visual Metaphors	31
2.5	Summary	32
	Exercises	32
3	Static Program Visualization	35
3.1	Textual Representations	35
3.1.1	Pretty Printing	35
3.1.2	Program as Publication	36
3.2	Diagrammatic Representations	38
3.2.1	Jackson Diagrams	38
3.2.2	Control-Flow Graphs	40
3.2.3	Nassi-Shneiderman Diagrams	45
3.2.4	Control-Structure Diagrams	47
3.3	Visualizing the Results of Program Analyses	48
3.3.1	Static Analysis	48
3.3.2	Control-Flow Analysis	49
3.3.3	Data-Flow Analysis	50
3.3.4	Examples of Visualization of Analysis Results	53
3.4	Visualizing Software Architectures	56
3.4.1	Some Familiar Architectures	57
3.4.2	The Unified Modeling Language (UML)	58
3.4.3	Software Metrics	60
3.4.4	Software Visualization and Reverse Engineering	63
3.4.5	3D and Software Architecture	71
3.5	Summary	74
	Exercises	74
4	Dynamic Program Visualization	79
4.1	Dynamic Data Acquisition	79
4.1.1	How Is Runtime Data Collected?	80
4.1.2	What Runtime Data Is Collected?	80
4.1.3	Dynamic Data Acquisition in Java	81
4.2	Visualizing Dynamics	82
4.2.1	Fundamental Techniques	82
4.2.2	A First Example	83
4.3	Dynamic Architecture Visualization	85
4.3.1	Augmenting Static Diagrams	85
4.3.2	Generating Behavior Diagrams	86
4.4	Algorithm Animation	87
4.4.1	What Is It About?	87
4.4.2	Why Do People Animate Algorithms?	88
4.4.3	A Short History of Algorithm Animation	89

4.4.4	Some Animations Produced by X-Tango	90
4.4.5	3D for Algorithm Animation	95
4.4.6	Architectures of Algorithm Animation Tools	97
4.4.7	Abstract Algorithm Animation	99
4.4.8	Learning Scenarios	102
4.4.9	A Brief Introduction to SAMBA	105
4.5	Visual Debugging – Inspecting the Program State	108
4.5.1	Interactive Visual Unfolding	109
4.5.2	Traversal-Based Visualization	110
4.5.3	Memory Graphs and Memory Slices	111
4.5.4	Reference Patterns	114
4.6	Visual Testing – Detecting Possibly Buggy Program Code	115
4.6.1	Dynamic Program Slices	115
4.6.2	Visualizing Test Case Results	117
4.6.3	Web Service Flow Patterns	122
4.7	Summary	124
	Exercises	125
5	Visualizing the Evolution of Software Systems	129
5.1	Visualizing Changes in Software Metrics	130
5.1.1	SecSoft	131
5.1.2	Revision Towers	135
5.1.3	The Evolution Matrix	135
5.2	Visualizing Software Archives	136
5.3	Visualizing Structural Change	138
5.4	Visualizing Evolutionary Coupling	140
5.5	Visual Data Mining	144
5.6	Summary	146
	Exercises	147
6	Evaluation	149
6.1	Claims About Visualization Techniques	149
6.2	Quantitative Evaluation	149
6.3	Qualitative Evaluation	150
6.3.1	Evaluation Based on Gestalt Theory	151
6.3.2	Task-Oriented Evaluation	152
6.3.3	The Cognitive-Dimensions Framework	152
6.4	Educational Evaluation	154
6.5	Some Interesting Empirical Results	157
6.6	Summary	159
	Exercises	160

7 Conclusions	161
7.1 The Visualization Pipeline – Revisited	161
7.2 Further Reading and Resources	163
7.3 The Future of Software Visualization.....	165
References	169
Index	185