



# Contents

Preface	xi
List of Tutorials	xvii
Introduction	1
<b>I Elements of Interactive Programs</b>	<b>7</b>
Introduction to Part I	9
<b>1 Event-Driven Programming</b>	<b>13</b>
1.1 Control-Driven Programming . . . . .	14
1.2 Event-Driven Programming . . . . .	19
1.3 Triggering and Translation of Events . . . . .	24
1.4 Categories of Events . . . . .	27
1.5 Servicing of Events . . . . .	30
1.6 The Event-Driven Ball-Shooting Program . . . . .	32
1.7 Summary . . . . .	35
<b>2 Working with GUI APIs</b>	<b>37</b>
2.1 Our Application and Existing Libraries . . . . .	38

2.2	GUI Elements . . . . .	39
2.3	Building a GUI Application . . . . .	41
2.4	Examples: FLTK and MFC . . . . .	43
2.5	Implementation Notes . . . . .	45
2.6	Tutorials and Code Base . . . . .	48
<b>3</b>	<b>A Simple Graphics Program</b>	<b>75</b>
3.1	Coordinate Positions and Vertices . . . . .	77
3.2	A Computer Graphics Solution . . . . .	79
3.3	Lessons Learned . . . . .	84
3.4	Further Examples . . . . .	85
<b>4</b>	<b>Working with Graphics APIs</b>	<b>93</b>
4.1	Relationship between Graphics and GUI APIs . . . . .	95
4.2	Programming Graphics APIs . . . . .	96
4.3	Understanding Tutorials 3.1 and 3.2 . . . . .	100
4.4	Abstraction of Graphics API . . . . .	103
<b>5</b>	<b>The Model-View-Controller Architecture</b>	<b>109</b>
5.1	The Model-View-Controller Framework . . . . .	110
5.2	Applying MVC to the Ball-Shooting Program . . . . .	112
5.3	Expanding the Ball-Shooting Program . . . . .	118
5.4	Interaction among the MVC Components . . . . .	120
5.5	Applying the MVC Concept . . . . .	121
5.6	Tutorials and Implementations . . . . .	122
<b>6</b>	<b>Applying to Real-World Applications</b>	<b>147</b>
6.1	PowerPoint . . . . .	147
6.2	Maya . . . . .	149
<b>II</b>	<b>Essential Concepts: Presented in 2D</b>	<b>153</b>
	<b>Introduction to Part II</b>	<b>155</b>
<b>7</b>	<b>Attributes and Behaviors of Primitives</b>	<b>157</b>
7.1	Types of Primitives . . . . .	158
7.2	Working with Color . . . . .	162
7.3	Programming Geometric Primitives . . . . .	163
7.4	Abstraction of Behavior: A Primitive Hierarchy . . . . .	172
7.5	Collisions of Primitives . . . . .	182

Contents	vii
7.6 Collection of Primitives . . . . .	188
<b>8 Transformation Operators</b>	<b>193</b>
8.1 The Translation Operator . . . . .	194
8.2 The Scaling Operator . . . . .	198
8.3 The Rotation Operator . . . . .	204
8.4 Affine Transformations . . . . .	209
8.5 Some Mathematics of the Transform Operators . . . . .	210
8.6 Tutorials on Transformation Operators . . . . .	215
<b>9 Combining Transformation Operators</b>	<b>225</b>
9.1 Concatenation of Operators . . . . .	226
9.2 Inverse Transformation . . . . .	229
9.3 Pivoted Transformations . . . . .	231
9.4 Programming Transformations with Graphics APIs . . . . .	236
<b>10 Coordinate Systems</b>	<b>257</b>
10.1 Understanding Tutorial 3.1 . . . . .	258
10.2 Device and Normalized Coordinate Systems . . . . .	265
10.3 The World Coordinate System . . . . .	266
10.4 The World Coordinate Window . . . . .	273
10.5 Inverse Transformation . . . . .	287
<b>11 Hierarchical Modeling</b>	<b>293</b>
11.1 Motivation . . . . .	294
11.2 The SceneNode Class . . . . .	299
11.3 Scene Trees and Scene Graphs . . . . .	311
11.4 The Object Coordinate System . . . . .	317
11.5 Simple Animation with the SceneNode Class . . . . .	333
<b>12 Making the Applications Interesting</b>	<b>337</b>
12.1 Orientation of Objects . . . . .	338
12.2 Alpha Blending and Transparency . . . . .	345
12.3 File Texture Mapping . . . . .	351
<b>III The Third Dimension</b>	<b>365</b>
Introduction to Part III	367



<b>13</b>	<b>A Simple 3D Application</b>	<b>369</b>
13.1	3D Coordinate Systems . . . . .	371
13.2	The Model and the Scene . . . . .	372
13.3	A Computer Graphics Simulation . . . . .	374
<b>14</b>	<b>The Camera</b>	<b>379</b>
14.1	A Computer Graphics Camera . . . . .	380
14.2	The Visible Volume . . . . .	386
14.3	The Coordinate Transformation Pipeline . . . . .	396
14.4	The World Transform: OC to WC . . . . .	397
14.5	The Eye Transform: WC to EC . . . . .	398
14.6	The Projection Transform: EC to NDC . . . . .	402
14.7	3D NDC-to-2D Device Transform . . . . .	404
14.8	Re-Examining Tutorial 13.1 . . . . .	405
<b>15</b>	<b>Working with the Camera</b>	<b>409</b>
15.1	UWBGL Camera Implementation . . . . .	413
15.2	Working with Multiple Cameras . . . . .	422
15.3	Manipulating the Camera . . . . .	422
15.4	DC-to-WC Transformation . . . . .	436
15.5	2D Versus 3D Coordinate Transformation Pipeline . . . . .	444
<b>16</b>	<b>Graphics Programming in 3D</b>	<b>447</b>
16.1	Graphical Primitives for the Third Dimension . . . . .	448
16.2	Rotation in 3D . . . . .	457
16.3	Orientation in 3D . . . . .	464
16.4	Simple Scene Graph in 3D . . . . .	479
16.5	Scene Graph and Orientation . . . . .	480
16.6	Collision in 3D . . . . .	485
16.7	Selection in 3D . . . . .	487
<b>A</b>	<b>Material and Illumination</b>	<b>489</b>
<b>B</b>	<b>Vectors</b>	<b>493</b>
B.1	Vector Basics . . . . .	493
B.2	Vector Products . . . . .	498
B.3	Vector Examples . . . . .	500
B.4	Orthonormal Matrices . . . . .	505
<b>C</b>	<b>Summary of Library Version Changes</b>	<b>507</b>

Contents

ix



Index

537