

Contents

Section I: Basics of Designing Virtual Reality Systems	1
● Chapter 1. Introduction: Virtual Reality in a Nutshell	3
■ What Is Virtual Reality?	3
■ Goals and Applications of Virtual Reality	3
■ Two Pillars of VR: Presence and 3D Multimodal Interaction	5
■ Building a Virtual Reality System	8
■ About This Book	10
■ Final Notes	11
■ Acknowledgments	12
■ Summary and Pondering Points	12
● Chapter 2. Requirements Engineering and Storyboarding	14
■ Example: Ship Simulator Design	19
■ Summary and Pondering Points	26
● Chapter 3. Object and Scene Modeling	27
■ Object Modeling	27
■ Scene Construction	36
■ Object Placement	36
■ Multiple Frames of Reference	42
■ Re-Expressing Coordinates	43
■ Function and Behavior Modeling	47
■ Ship Simulator Example Revisited	49
■ Summary and Pondering Points	50
● Chapter 4. Putting It All Together	53
■ Example Continued: Ship Simulator, Level 2 Design	56
■ Summary and Pondering Points	65

● Chapter 5. Performance Estimation and System Tuning	66
■ Tuning with LOD Models.....	66
■ Presence/Special Effects	67
■ Using Images and Textures.....	68
■ Summary and Pondering Points.....	73
Section II: Creating the Virtual Reality	75
● Chapter 6. Output Display	77
■ The Human Visual System	77
■ Human Depth Perception and Stereoscopy.....	81
■ Visual Display Systems.....	88
■ Human Aural System.....	98
■ Aural Display Systems.....	103
■ Haptics.....	105
■ Stimulation of Other Modalities I.....	108
■ Summary and Pondering Points.....	113
● Chapter 7. Sensors and Input Processing	115
■ Trackers.....	116
■ Event Generators	118
■ Sensor Errors and Calibration	120
■ Summary and Pondering Points.....	121
● Chapter 8. 3D Multimodal Interaction Design	122
■ Why Go 3D Multimodal?	122
■ Structured Approach to Interaction/Interface Design	123
■ Metaphors	125
■ Interface Design	126
■ Multimodality	128
■ Case Studies	130
◆ Ship Simulator	130
◆ Immersive Authoring	131
◆ Tabletop Computing.....	134
◆ Selection and Manipulation	137
◆ Navigation	142
◆ Menu Selection and Invocation	143
◆ Whole Body Interaction	147
◆ Tangible Interface	148
◆ Alphanumeric Input	150
■ Summary and Pondering Points.....	152
● Chapter 9. Simulation I: Collision Detection	153
■ Handling Collision.....	153

- Collision Detection with Line Segment(s) 155
- Collision Among Polygonal Models 160
- Bounding Volumes 166
- Building a Bounding Volume 169
- Bounding a Volume Hierarchy..... 172
- Collision Among Bounding Volumes 173
- Summary and Pondering Points 178

- **Chapter 10. Simulation II: Physics-Based Motion
and Collision Response** 179
 - Center of Gravity and Moment of Inertia 179
 - Linear and Rotational Kinematics..... 185
 - Laws of Motion 187
 - Dynamics 191
 - Ad Hoc Collision Response..... 192
 - Physics-Based Collision Response 192
 - Real-Time Simulation Revisited 195
 - Deformation 196
 - Summary and Pondering Points 197

- **Chapter 11. Virtual Characters** 199
 - Form of a Character 199
 - Motion Control 200
 - Forward Kinematics 206
 - Inverse Kinematics 210
 - Summary and Pondering Points 213

- **Epilogue** 215
 - Other Areas of Virtual Reality..... 215
 - Is Virtual Reality Really Any Good? 216
 - Virtual Reality for Spatial Presence..... 216

- References 219
- Index 227