GAME DEVELOPMENT ESSENTIALS

GAME ARTIFICIAL INTELLIGENCE

John Ahlquist
Jeannie Novak

THOMSON
DELMAR LEARNING™

Australia Canada Mexico Singapore Spain United Kingdom United States

CONTENTS

Introduction ix

About the *Game Development Essentials* Series x
About *Game Development Essentials: Game Artificial Intelligence* x
Who Should Read This Book? xi
How Is This Book Organized? xii
How To Use This Text xiv
- Key Chapter Questions xiv
- Notes xiv
- Sidebars xiv
- Quotes xv
- Tips xv
- Case Studies xv
- Profiles xvi
- Chapter Review xvi

About the Companion DVD xvi
About the Instructor's Guide xvii
About the Author xvii
Acknowledgments xviii
Questions and Feedback xx
Dedication xxi

Part I: Creating Behaviors 1

Chapter 1 History and Concepts: how did we get here (and where is *here*, anyway?) 3

- Key Chapter Questions 3

Game AI vs. Computer Science AI 4
A Brief Overview of Computer Science AI 4
- Mechanical Automata 5
- Programmable Systems 6
- AI Development 7
- Fuzzy Logic 8
- Knowledge-Based and Expert Systems 9

History of Game AI Agents 11
Early Agents 13
History of Game AI Implementation Methods 17
Which Brings Us to . . . Here 24
Intelligent Agents 24
AI Programming Concepts 25
Algorithm 26
Heuristic 26
Data-Driven Design and Rapid Iteration 27
Object-Oriented Design 29
Control Methods 34
Chapter Review 37

Chapter 2 AI Agents: creating behavior using a finite state machine 39
Key Chapter Questions 39
Creating and Controlling AI Behaviors 40
Behavior: A Sequence of Actions 40
Dynamic Sequences 41
Finite State Machine 41
Representative AI States 43
SAGE State Machine 44
MoveTo: A Single-State Behavior 45
Attack: A Multiple-State Behavior 46
Matching States to Game Design 49
Designing an FSM 49
Transitions 50
Internal 51
External 52
Deferred 52
Immediate 54
An AI System Controlled by a Finite State Machine 56
Sample Application 57
Agent Design 58
AI Module 61
Speculative Features 63
Attraction 64
Hidden Cost 65
Chapter Review 67

Chapter 3 Complexity & Broad Scope: multiple states and hierarchical state machines.....69

Key Chapter Questions..... 69

Hierarchical Finite State Machine.....70
Example State: Attack.....71
Procedural Transition Generation.....71
Models.....72
Externally Generated Transitions.....72
Internally Generated Transitions.....73
Active State Generated Transitions.....73
Advantages and Drawbacks.....74
Consider Multiple States.....76
Child States Compete.....77
Retaliation.....80
Parent State Control.....80
Abstractions and Models.....83
State Machines.....83
State Search Goals.....84
Advantages and Drawbacks of the State Machine Model.....84
State Suspend and Continue.....85
Multiple State Machines.....86
Goal-Oriented AI Model.....87
Goal Operation.....87
Goal Hierarchy.....88
Goal Selection.....89
Action Selection.....90
Obtaining a Tool.....93
Handling Complexity.....94
Chapter Review.....95

Part II: Controlling Behaviors . . . 97

Chapter 4 Customizing AI Systems: allowing others to modify and implement the AI 99

Key Chapter Questions..... 99

Black Box and White Box Systems.....100
Black Box Design.....105
White Box Design.....106
Development Techniques.....109

Scripting Systems. 112
Text Scripting Languages. 113
Graphical User Interface Scripting Languages. 118
Benefits of Scripting Over C++. 123
Using Scripting in a Game. 124
Script Interface Design. 127
Object-Oriented Scripting. 127
Benefits of Using a Scripting Language 128
Chapter Review 131

Chapter 5 Expert Systems: capturing high-level knowledge and improving behavioral control 133
Key Chapter Questions. 133
Expert Systems Defined. 134
Expert System Components. 134
Knowledge Base 135
Working Memory. 137
Inference Engine. 138
Capturing High-Level Knowledge. 139
Analysis 140
Empirical Study 140
The Power of Expert Systems. 141
Challenges. 142
Embedded Expert Systems. 151
Sample Rule Set 152
Modifying the Game State. 152
Combining Data-Driven and Rule-Based Systems. 156
Structure Location 157
Order of Creation. 157
Additional Base-Building Rules. 157
Chapter Review 159

Chapter 6 Pathfinding: allowing agents to properly find and follow paths 161
Key Chapter Questions. 161
Pathfinding Systems. 162

Pathfinding Networks 162
Regular Grids 162
Arbitrary Grids 164
Path Planning 166
Path Searching 168
Table Lookup 168
Search Algorithms 170
Path Following 184
Leave Space Between Agents 185
Path Around Other Agents 186
Assume No Path Exists 187
Request Agents to Move 187
Chapter Review 189

Part III: Advanced Topics & Applications 191

Chapter 7 Advanced Pathfinding Techniques: improving performance and quality 193
Key Chapter Questions 193
Pathfinding Performance Optimization 194
Failed Pathfind Operations 194
Zone Mapping 197
Virtual Players & Waypoint Paths 203
Group Pathfinding 206
Starting Point 208
Gather 208
Retreat 209
Heterogeneous Groups 209
Hierarchical Pathfinding 209
Intermediate Destinations: Creating Shorter Paths 211
Pruning the Network 212
Bigger Is Better 213
Chapter Review 214

Chapter 8 Looking Smart: maximizing perception of intelligence 213
Key Chapter Questions 213
The Appearance of Intelligent Behavior 214
The ELIZA Effect 215

Make the AI Visible 219
Eliminate Invisible AI Activity 220
Game Performance Efficiency 220
Game Development Efficiency 224
Avoid Behavior That Looks Mechanical 224
Provide AI That Makes Choices 226
Provide Multiple Options 226
Minimize Random Behavior 227
Provide Strategic Choices 227
Use Cues That Imply Intelligence 231
Scripting 232
Simple Systems 232
Implying an AI Behavior 236
Chapter Review 237

Chapter 9 Putting It All Together: designing and building quality game artificial intelligence 245

Key Chapter Questions 245

Game AI Requirements 246
Simple Agents, Smart Virtual Players 246
Smart Groups of Agents 247
Solo Agents 248
Agents and Virtual Players 249
A Hypothetical Case Study—*Titanium* 250
Game Development Environment 252
Initial Game Design 252
Define the AI Feature Set 254
Design the AI Systems 255
Implement the AI Systems 263
Iterate Details and Design 266
Careers in Game Artificial Intelligence 270
AI Programmer 271
AI Designer 275
Future of Game AI 279
Chapter Review 281

Resources 282

Index 290