## Contents

Preface, xvii

## SECTION I Procedural Generation

CHAPTER 1 • When and Why to Use Procedural Generation	3
DARREN GREY	
PLANNING WHEN TO USE PROCEDURAL GENERATION	3
Integral	3
Drafting Content	4
Modal	5
Segmented	5
WHEN PCG IS A BAD IDEA	5
Quality Assurance	6
Time Restrictions	6
Authored Experience	7
Multiplayer	7
Just Random	8
Overreliance on PCG	8
WHY USE PROCEDURAL GENERATION?	8
Utilitarian	8
Unique	10
CHAPTER 2 • Managing Output: Boredom versus Chaos	13

CHAPTER 3 Aesthetics in Procedural Generation	23
LIAM WELTON	
ATMOSPHERE IN SUNLESS SEA	24
ESTABLISHING THE RULES	25
BLURRING THE BOUNDARIES	26
THE RESULT	27
CHAPTER 4 Designing for Modularity	29
JASON GRINBLAT	
MODULES AND GESTALTS	29
ASSEMBLY MECHANISMS AND GESTALT SPACES	30
ENABLING PLAY	33
Mechanics as Shared Substrates	33
Orthogonality	35
Equivalence of Impact	37
PLOTTING DESIRABLE GESTALTS	38
INSERTING MEMORABLE ASYMMETRY	40
REFERENCE	41
CHAPTER 5 • Ethical Procedural Generation	43
Dr. Michael Cook	
TALKING IN CODE	44
THE BIG WIDE WORLD	46
YOU ARE WHAT YOU EAT	50
TALKING THE TALK	51
THE FUTURE	54
SECTION II Procedural Content	
CHAPTER 6 • Level Design I: Case Study	57
CHRIS CHUNG	
OVERVIEW	58
THE RULES	59

HOW IT WORKS	60
CONCLUSION	62
CHAPTER 7 • Level Design II: Handcrafted Integration	63
JIM SHEPARD	63
STANDARD DUNGEONS	63
CRYPT GENERATION	66
BEST PRACTICES	68
DUNGEONMANS DUNGEON GENERATION PSEUDOCODE	
DUNGEONMANS CRYPT GENERATION PSEUDOCODE	70
CHAPTER 8 • Level Design III: Architecture and Destruction	73
Evan Hahn	
ARCHITECTURE GENERATION	74
Step 1: Calculate the Bounding Box	75
Step 2: Split the Box into Regions	75
Step 3: Skim Perimeter Regions	76
Step 4: Place Connections	78
Step 5: Assign Region Types	80
Step 6: Make Adjustments	81
Step 7: Generate the Regions	81
DISCUSSION	82
CHAPTER 9 • Cyclic Generation	83
Dr. Joris Dormans	
CYCLES	84
USING GRAPHS TO EXPRESS CYCLES	84
PATTERNS	89
IMPLEMENTATION	89
ASIDE: LOCK-AND-KEY ATTRIBUTES	91
Locks Might Be Conditional, Dangerous, or Uncertain	91
Locks Are Permanent, Reversible, Temporary, or Collapsing	92
Locks Might Be Valves or Asymmetrical	92
Locks and Keys Can Be Safe or Unsafe	92

Keys Can Be Single Purpose or Multipurpose	92	CHAPTER 12 Procedural Logic	11
Keys Are Particular or Nonparticular	93	BEN KANE	
Keys Might Be Consumed or Persistent	93	BACKGROUND	11
Keys Might Be Fixed in Place	93	USUAL APPROACH TO PROCEDURAL GENERATION	12
TILEMAPS	93	A DIFFERENT APPLICATION: PROCEDURAL LOGIC	12
DISCUSSION	95	HOW THE RULE LOGIC IS GENERATED	12
	0.7	Trivial Case	12
CHAPTER 10 • Worlds	97	Countable Problems	12
DR. MARK R. JOHNSON	0.8	Not So Trivial: Procedural Logic	12
BRIEF HISTORY OF WORLD GENERATION	101	Generating Rules	12
WHY MAKE WORLDS?	101	Queries: Asking Questions	12
Exploration	101	Solutions: Taking Action	12
Expansive or Complex Worlds	102	IMPROVING THE PROCESS	12
Gameplay Variation	103	Better Queries	12
QUALITATIVE PROCEDURAL GENERATION	103	Compound Queries	12
CHAPTER 11 • Puzzles	107	Query Contexts	12
DANNY DAY		Better Solutions	12
PROCEDURALLY GENERATING PUZZLES	107	RIGGING THE DECK: RANDOM THAT FEELS GOOD	12
Puzzle-Spaces	108	Dealing with Degenerates	12
Desired Outputs	108	Avoiding the Impossible	13
PUZZLE GENERATION APPROACHES	109	PUTTING IT ALL TOGETHER	13
Random Start State	109	CONCLUSION	13
Backward from Goal State	110	CHAPTER 13 • Artificial Intelligence	13
Heuristics	110	Dr. Mark R. Johnson	
Extra Bonus: Permutations	111	UNPREDICTABILITY AND ARTIFICIAL INTELLIGENCE	13
DESKTOP DUNGEONS, THE PUZZLE ROGUELIKE	112	MOVEMENT AND COMBAT	13
More Puzzle than Roguelike?	112	AMBIENT BEHAVIOR	13
More Roguelike than Puzzle?	112	EMERGENT PHENOMENA	13
PLAYER HOPE AS A RESOURCE	113	CONVERSATIONS	13
Guaranteeing Solvability	114	Dialects	13
Generating Hope	115	Conversation System	14
CONCLUSION	117	CONCLUSION	14

CHAPTER 14 Procedural Enemy Waves	143
WYATT CHENG	
METHOD 1: SPAWN BY TIMER	144
Spawn by Timer Pseudocode	144
Commentary	144
Key Characteristics	146
METHOD 2: SPAWN ON COMPLETION	146
Spawn on Completion Pseudocode	146
Commentary	147
Key Characteristics	147
METHOD 3: CONTINUOUSLY ESCALATING TOTAL	148
Continuously Escalating Total Pseudocode	148
Commentary	149
Key Characteristics	150
METHOD 4: HITPOINT PROGRESSION	150
Hitpoint Progression Pseudocode	150
Commentary	151
Key Characteristics	151
CONCLUSION	152
CHAPTER 15 Generative Artwork	153
LOREN SCHMIDT	
TECHNIQUES	154
PERCEPTION OF INTENT	158
CHAPTER 16 Generative Art Toys	161
KATE COMPTON	
BUILDING ART TOYS, FOR EXPERTS AND NOVICES	161
EXPERIENCE OF ART TOYS	163
TRADING CONTROL FOR POWER	164
DESIGN AND CONSTRUCTION OF ART TOYS	166
Inputs	166
Data and Transformations	168

Points and Rotations	168
Connectivity and Meshes	168
Gestural Curves	168
Forces and Acceleration	169
Rendering	169
OUTSIDE THE GENERATOR: JUDGMENT, SHARING,	107
AND CURATION	172
CONCLUSIONS: CREATIVITY FOR ANYONE	173
CHAPTER 17 • Audio and Composition	175
Bronson Zgeb	
PROCEDURAL AUDIO IN SKIPPING STONES	175
Sampling	175
Pitch	176
Implementation	177
PROCEDURAL COMPOSITION IN SKIPPING STONES	177
Beat	178
Scale	179
Steps	179
Chords	181
Motif and Repetition	181
CONCLUSION	183
SECTION III Procedural Narrative	
CHAPTER 18 Story and Plot Generation	187
BEN KYBARTAS	
GRAMMARS AND STORY GRAMMARS	188
GAME WORLD	190
STORY MODEL	191
RULE DESIGN	192
SECONDARY REWRITE RULES	194
GAME WORLD SIMULATION	195

The state of the s	AND DESCRIPTION OF THE PERSON NAMED IN					
WALKE THE PARTY OF	-	M		-	M	æ
XII III (	0		8 N	and the		п
A S S DATE Y			28			10

METRIC-GUIDED GENERATION	196	PITFALLS	22
CONCLUSIONS	197	Overgeneralization	22
	100	Overrealism	22
CHAPTER 19 Emergent Narratives and Story Volumes	199	Untamed Simulation	22
JASON GRINBLAT	100		
MOTIVATION	199	SECTION IV The Procedural Future	
THE VOICE IN THE MACHINE	201	CHAPTER 22 • Understanding the Generated	23
FIASCO: A CASE STUDY	203	GILLIAN SMITH	20
UNPACKING YOUR THEMES.	205	EXPRESSIVE RANGE AND GENERATIVE SPACES	23
GRIST FOR THE NARRATIVE MILL	207	QUALITIES OF THE GENERATED	23
CHAPTER 20 Poetry Generation	209	Types of Qualities	23
HARRY TUFFS		Example	23
		Formalizing Qualities into Metrics	23
CHAPTER 21 Characters and Personalities	215	Example	23
EMILY SHORT		Metrics versus Requirements	23
INTRODUCTION	215	QUALITIES OF THE GENERATOR	23
SOURCE MATERIAL	216	VISUALIZING EXPRESSIVE RANGE	23
REALIZATION	217		
Selecting Dialogue	217	Histograms	23
Layering Dialogue Features	218	Example Distance Board Chastering	24
Character and World Interaction	220	Distance-Based Clustering	24
CREATION	220	CONCLUSION	24
Orthogonal	221	REFERENCES	24
Mechanically Significant	221	CHAPTER 23 • Content Tools Case Study	24
Easy to Communicate	222	Kepa Auwae	
Meaningful in Combination	222	SYSTEM OVERVIEW	24
RECURRING STRATEGIES	223	EXAMPLE ROOM	24
Combining Output from Several Layers of Simulation or			
Gameplay	223	CHAPTER 24 - Automated Game Tuning	25
Bringing Character into Every Interaction	223	AARON ISAKSEN	
Juxtaposing Events and Interpretation	224	STEP 1: SET PARAMETERS	25
Callbacks to Earlier Events	225	STEP 2: GENERATE THE GAME LEVEL	25

COMETICE - AIM

Co	nten	its		XV
CO	IIICI	113	District Co.	AV

STEP 3: SIMULATE THE GAME	255
STEP 4: ANALYZE THE DATA	258
STEP 5: VISUALIZE THE DATA AND MAKE ADJUSTMENTS	261
CONCLUSION	263
ACKNOWLEDGMENTS	264
	0.65
CHAPTER 25 Generating Rules	265
DR. MICHAEL COOK	0.5.5
MIX AND MATCH	266
GAME DESIGN 101	267
THROWING OUT THE RULEBOOK	269
CHAPTER 26 • Algorithms and Approaches	271
BRIAN BUCKLEW	
RANDOM NUMBERS	271
Pseudorandom Number Generators	271
Making Use of Repeatable Series	272
Seeds and Hashing	273
Rolling Dice	274
Normal Distributions	275
Weighted Distributions	277
HEIGHTMAPS	279
Box Linear Filters	279
Midpoint Displacement	280
Perlin and Simplex Noise	281
SEQUENCE GENERATION	283
Lindenmayer Systems (L-Systems)	283
Markov Chains	284
FILLING SPACE	286
Random Walks	286
One-Dimensional Random Walks	286
Two-Dimensional Random Walks	287

Cellular Automata	288
Settling	291
Wang Tiles	291
PARTITIONING SPACE	293
Binary Space Partition	293
Voronoi Diagrams	295
Dijkstra Maps	296
Tree Mapping	297
PUTTING IT ALL TOGETHER	298
	230
CHAPTER 27 • Meaning	301
Dr. Mark R. Johnson	
MEANING IN GAMES	302
MEANINGLESSNESS IN GAMES	304
DESIGNER AND PLAYER MEANING	306
MEANING IN QUALITATIVE PROCEDURAL GENERATION	308
CONCLUSION	311
	911

INDEX, 313