



BUILDING INTERACTIVE WORLDS IN 3D



Virtual Sets and Pre-Visualization
for Games, Film & the Web

Jean-Marc Gauthier



Virtools™
The Behavior Company



Building Interactive Worlds in 3D

Virtual Sets and Pre-Visualization for Games, Film, and the Web

Building Interactive Worlds in 3D

Virtual Sets and Pre-Visualization for Games, Film, and the Web

Jean-Marc Gauthier



ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Focal Press is an imprint of Elsevier




Acquisition Editor: Amy Jollymore
Project Manager: Anne B. McGee
Assistant Editor: Cara Anderson
Marketing Manager: Christine Degen
Cover Design: Eric DeCicco
Composition: SNP Best-set Typesetter Ltd., Hong Kong
Printer: Hing Yip Printing Co., Ltd.

Focal Press is an imprint of Elsevier
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
Linacre House, Jordan Hill, Oxford OX2 8DP, UK

Copyright © 2005, Jean-Marc Gauthier. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone: (+44) 1865 843830, fax: (+44) 1865 853333, e-mail: permissions@elsevier.com.uk. You may also complete your request on-line via the Elsevier homepage (<http://elsevier.com>), by selecting "Customer Support" and then "Obtaining Permissions."

 Recognizing the importance of preserving what has been written, Elsevier prints its books on acid-free paper whenever possible.

Library of Congress Cataloging-in-Publication Data

Gauthier, Jean-Marc, 1960–

Building interactive worlds in 3D : pre-visualization for games, film, and the Web /
Jean-Marc Gauthier.

p. cm.

Includes bibliographical references and index.

ISBN 0-240-80622-0 (alk. paper)

1. Computer games—Programming. 2. Three-dimensional display systems.
3. Virtual reality. I. Title.

QA76.76.C672.G369 2005

794.8'16693—dc22

2004061933

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

ISBN: 0-240-80622-0

For information on all Focal Press publications
visit our website at www.focalpress.com

05 06 07 08 09 10 10 9 8 7 6 5 4 3 2 1

Printed in China



Table of Contents

Acknowledgments	xiii
Contributors	xv
Preface	xix
Introduction	xxi

Chapter 1

Emergence of Virtual Spaces	1
1 Emergence	1
2 Discussion about Virtual Spaces	1
2.1 Let's Start the Discussion	2
2.2 Notes on the Discussion	10

Chapter 2

The Basic 3D Kit	13
1 The Roadmap	13
2 The Making of Cyclop, an Interactive Character in Maya	13
2.1 Tour of Maya's Interface	14
2.2 Modeling	16
2.3 Materials and Textures	32
2.4 Building a Skeleton with Inverse Kinematics	39
2.5 Creating a Walk Animation	50
2.6 How to Export the Character to Virtools	55
2.7 What Did You Learn in This Tutorial?	57
3 Creating a 3D Immersive Environment	58
3.1 Creating the Ground	59
3.2 Painting the Trees	60
3.3 Painting Grass	61
3.4 Conversion of 3D Models to Polygonal Meshes	63
3.5 Reducing the Number of Polygons	64
3.6 Materials and Textures	65
3.7 How to Export the Scene to Virtools	66

3.8	Setting Up the Scene in Virtools.....	68
3.9	Loading Textures from Maya in Virtools	71
3.10	Creating a Skybox.....	74
3.11	Using Textures with Alpha-Channels.....	74
3.12	Importing a Character.....	77
3.13	The Character Stands on the Floor.....	78
3.14	The Character Walks.....	78
3.15	What Did You Learn in This Tutorial?	81

Chapter 3

Interactive Textures and Lighting Design.....		83
1	Introduction.....	83
1.1	Bitmaps and Procedural Images.....	83
1.2	Shaders.....	84
1.3	Displacement Maps.....	88
1.4	Procedural Painting.....	89
1.5	Particle Animation	90
2	Texture Primer: Creating a Skybox	90
2.1	Origins of the Skybox.....	90
2.2	Skybox Tutorial	92
2.3	Design of a Skybox in Lightwave Modeler	92
2.4	Create a Scene with Lights and Cameras in Lightwave	100
2.5	Creating a Database to Manage 3D Assets in Virtools.....	104
3	Create Interactive Textures: Bitmaps and Procedural Images	104
3.1	Blending Textures Looped in Time	104
3.2	Blending Textures Controlled by Viewer's Input	110
3.3	Scrolling Textures.....	112
3.4	Scrolling Texture with a Transparent Background.....	112
3.5	Playing Movie Clips in a Loop Controlled by the Viewer	116
3.6	Playing Movie Clips Controlled by the Viewer	118
3.7	Using a Live Video from a Virtual Camera.....	118
3.8	Texturing with a Random Live Video Signal.....	120
3.9	Texturing with Live Video Signals Controlled by the Mouse.....	121
3.10	Controlling a Texture with an Animated Character	121
3.11	Texturing with Two Distinct Live Video Signals	123
3.12	Texturing with Two Live Video Signals Reflected in a Mirror....	125
3.13	Texturing with Live Video Stream from a Video Camera	126
4	Programmable Shaders.....	127
4.1	The X-Ray Shader, Created by Zach Rosen.....	128
4.2	Focus and Defocus.....	133

5	Displacement Maps	134
6	Vertex Painting	137
7	Procedural Painting	138
7.1	Painting in 3D with One Texture	138
8	Examples of Particle Animation	142
8.1	Designing a Planar Particle Emitter	142
8.1.1	Creating the Particle Emitter.....	142
8.2	Designing Behaviors for Flying Particles	142
8.2.1	Particle Emitters	142
8.2.2	Particle Deflectors	146
8.2.3	3D Objects Can Replace Textures in a Particle Animation Setup	147
9	Design of a Futuristic City	148
9.1	Designing the City	149
9.1.1	Creating Textures in Photoshop®	149
9.1.2	Modeling the Cityscape in Bryce	149
9.1.3	Textures, Lights, and Cameras.....	151
9.2	Particle Animation and Texture Blending in Vrttools.....	151
9.2.1	Texture Blending	151
9.2.2	Particle Animation of the Traffic of Flying Vehicles	153
9.2.3	Particle Animation of the Fires.....	153

Chapter 4

Kinematics	155
1 Introduction	155
1.1 Kinematics	155
1.2 Key-Frame Animations	156
1.3 Why Use Event-Driven Motions?	158
1.3.1 Hybrid Animation Systems.....	158
1.3.2 Parametric Animations	159
1.4 Using Pseudophysics.....	160
1.5 Virtual Worlds with Physics	162
1.6 Moving Physicalized 3D Objects.....	163
1.6.1 Translation with Physics.....	163
1.6.2 Rotation with Physics	164
1.6.3 Adding New Objects to a Simulation with Physics....	165
2 Creating Simple Motions and Manipulations	165
2.1 Rolling Stones.....	166
2.2 Multiple Collisions	167

2.3	Driving	173
2.3.1	Driving with Pseudophysics.....	173
2.3.2	Driving a String of Balls with Physics.....	173
2.4	Springs.....	175
2.4.1	Setting Up Physics for the Falling Object	177
3	Mesh Deformations	177
3.1	Twisting and Bending	180
3.1.1	Twisting	181
3.1.2	Bending.....	182
3.2	Applying Noise to a Mesh.....	183
3.3	Interactive Displacement of Vertices of a Mesh with a Mouse	183
3.4	Moving One Vertex at a Time by Hand.....	185
4	Complex Moving Structures	187
4.1	Snake	187
4.1.1	Building the Snake.....	188
4.1.2	Driving the Snake	192
5	Inverse Kinematics.....	192
5.1	Bird	193
5.2	The Hand	197
6	Motion Planning	200
6.1	"3D Hand with a Pendulum" Project.....	201
6.2	Path Finding.....	205
6.2.1	Setting Up a Character with Path Finding on a Terrain	207
6.2.2	Moving Goals through Time.....	209
7	Conclusion	216

Chapter 5

Interactive Paths		217
1	Story of a Famous Path	217
1.1	Designing Paths	217
1.2	Managing Paths	219
2	Paths Tutorials.....	222
2.1	How to Set Up the Path of an Insect Flying Along the Branch of a Tree.....	222
2.2	Controlling the Speed of a Camera on a Path.....	226
2.3	Interactive Motion Control of a Camera on a Path	228
2.4	Cameras Can Jump from One Path to Another.....	231
2.5	Viewers Can Jump from One Camera to the Other.....	232

2.6	How to Switch Cameras on the Same Path	234
2.7	How a Moving Object on a Path Can Detect and Avoid Obstacles	237
2.8	How to Record a Path on the Fly.....	239
3	The Donut Tutorial: Setting Up a Camera Inside an Interactive Race Track	242
3.1	Conceptual Design.....	243
3.2	Let's Start the Tutorial.....	245
3.2.1	Conceptual Design	245
3.2.2	Modeling a Donut-Shaped Ring	246
3.2.3	Texturing the Donut	246
3.2.4	Adding Lights and Cameras	248
3.2.5	Drawing a Path.....	249
3.2.6	Creating an Interactive Path	253
3.2.7	Controlling the Camera's Speed on the Path	255
3.2.8	Switching between Path Camera and Free Camera.....	255
3.2.9	Creating Interactive Textures	256
3.2.10	Adding an Additional Top View Helps to Keep Track of the Locations of Cameras on the Circuit	257

Chapter 6

Virtual Cameras	259
1 Introduction	259
1.1 Relationships between Virtual Cameras and the Environment of a Scene	260
1.2 The Psychology of the Viewer.....	263
1.3 Cameras are Rarely Working Alone.....	265
2 Building Virtual Cameras.....	269
2.1 Motion Stabilization	271
2.2 Virtual Cinematography.....	272
2.2.1 Character-Dependent Camera	273
2.2.2 Camera System Independent from Characters	274
3 How to Design Behaviors for Interactive Cameras that Produce the Same Effect as Cameras Found in Movies.....	278
3.1 Notes about <i>Rear Window</i> by Alfred Hitchcock.....	278
3.2 The Design of the Hitch Camera	278
3.2 Notes about <i>Paths of Glory</i> by Stanley Kubrick.....	285
3.4 The Design of a Maze Camera	286
3.5 Notes about <i>L'Avventura</i> by Antonioni.....	294
4 Conclusion	296

Chapter 7**Advanced Virtual Cameras and Their Environments 299**

1	Conceptual Design	299
1.1	Step 1: Conceptual Design	302
1.2	Step 2: Cameras and Navigation	302
1.3	Step 3: The Following Questions Are Related to the Viewer's Experience.....	304
2	Advanced Virtual Camera Development for the Diner Project.....	304
2.1	Step 1: Diner: Conceptual Design	306
2.2	Step 2: Cameras and Ways to Navigate Inside the Virtual World.....	314
2.3	Step 3: The Viewer's Experience.....	318
3	Virtual Camera Development for Nighthawks.....	319
3.1	Step 1: Conceptual Design	322
3.2	Step 2: Cameras and Navigation	324
3.3	Step 3: User Experience	328
4	Virtual Archeology at Aphrodisias 2003.....	329
5	Conclusion	338

Chapter 8**The Viewer's Experience, Interactive Installations, and Displays 339**

1	The Viewer's Interaction.....	339
2	Serial Input Devices.....	340
2.1	Technological Path for Serial Input Devices for a Virtual World.....	341
2.2	An Example of Virtual Space Installation Using an Ultrasound Sensor	343
2.3	Passing Variables from the Outside World Inside Virtools	344
2.4	Embedding a Virtools Scene Inside a Director Movie	348
2.5	Serial Communication	350
2.6	Sensors	352
2.7	Using Active X with Microsoft Visual Basic®	358
3	Using a Telephone as an Input Device	358
3.1	Technological Path	359
3.2	An Example of a Virtual Space Installation Using a Telephone in Virtools.....	360
4	Musical Instrument Digital Interface	363
4.1	Setting Up MIDI Channels	363
4.2	Sensor and Microcontroller	363

4.3	Virtools and Max Configuration	363
5	Data Glove	365
6	Infrared Sensors and Mouse-Driven Devices.....	381
7	Game Controller	382
8	Sound as an Input Device	382
8.1	Using a Threshold	382
8.2	Sampling Sound	384
9	Navigation	388
9.1	Example of Process	389
9.2	Interface Design and Content Management	390
9.2.1	Static Interfaces—Creating a Push Button and a Mouse Rollover	391
9.2.2	Dynamic Interfaces—Examples of 3D Interfaces	394
9.2.3	How to Create a 3D Mouse Pointer.....	395
9.2.4	How to Create an Interface Design for a 3D Character	398
10	Displays	399
10.1	Multiscreen Displays	399
10.2	Split View with Two Rendering Windows	400
10.3	Comics Split Views.....	400
10.4	Multiple Screens Display	401
11	Conclusion: The Shape of Things to Come	404
	Bibliography.....	409
	Index	413

Please email **AcademicBooksSupport@informa.com** with proof of purchase to obtain access to the supplementary content for this eBook. An access code and instructions will be provided.

Acknowledgments

After writing the last page of this book, I feel the same deep feeling of satisfaction that I experience when coming back home after an amazing trip. When I look back at the manuscript, I realize how much the process of writing this book was shared with many people that I would like to thank.

Thanks to my loving Hillary and Isabelle (Gauthier) who are my best advisers, coaches, reviewers, and supporters.

Thanks to several explorers of virtual spaces at ITP:

to Miro (Kirov) for his passion and his kindness,

to James (Tunick) for his out-of-this-world enthusiasm and talents to organize and communicate,

to Zach (Rosen) for asking the right questions and bringing amazing answers,

Thanks to Noa (Steimatsky) for her friendship,

to Amy Jollymore who nurtured the writing process and to Diane Cerra who introduced me to Amy,

to my students at ITP, Tisch School of the Arts, New York University, who tested the demos and influenced the presentation of many topics of this book,

to Ken Perlin, Fabien Bariti, Mike Olson, Eric Socolofsky, Antoine Schmitt, Ronald Hof, and Adrian Siminovitch, for their writings, their code, plugins, and expertise,

to Morekwe Molefe, Cara Anderson, Phil Bugeau, Bertrand Duplat, and Virgile Delporte, who helped with the making of the book and the companion CD-ROM,

to Florent Aziosmanoff, Le Cube, Michel Hamelin, Antenne 2, Martin Hash, Animation Master—Hash Inc., Thierry Martin, Bernard Morel, Ville de Nice, Martin Nachbar, Advanced Educational Services—School of Medicine—NYU, Christopher Ratte, Institute of Fine Arts—NYU, and to clients, collectors, curators, journalists, and collaborators who created opportunities, gave their support, rolled the drums, and to those who became friends,

to the people that came with me on this journey, and special thanks to the new readers of this book!

Contributors

Jean-Marc Gauthier, Architect D.P.L.G., Paris; M.P.S., New York University. Jean-Marc, an architect from France, is enjoying a significant freelance career as an interactive designer, code programmer, and new media consultant. His background is as technically oriented as it is rooted in design. JMG has been involved in virtual worlds since 1992, when he created “The Liquid Map,” an award winning real-time mapping simulator for decision makers. JMG has created virtual space installations inside museums and a low-cost, multiple-screen display for educational purposes, such as the Dynamic Virtual Patient and the Aphrodisias Project. JMG has designed several urban installations inside the city—for example, Nighthawks allows viewers to use cellular phones in order to control virtual spaces projected on a building.

JMG’s installations have been presented in museums and international conferences including the MAMAC (Nice), Chelsea art Museum (New York), American Museum of Moving Images (Queens), Massachusetts Institute of Technology’s International Conference on Design Computing and Cognition (Cambridge), Festival Iier Contact (Issy-les-Moulineaux), Villette-Numerique (Paris) and Siggraph.

JMG is the founder of www.tinkering.net, a consulting agency specialized in designing real-time 3D content for medicine, archeology, fashion, urban installations, virtual sets, and events. JMG has created interactive designs for New York University’s College of Medicine and Institute of Fine Arts, the Cousteau Society, the Institute for Environmental Studies at the University of Houston, the Four Oaks Foundation, USANetworks, the Academy for Educational Development, La Cite des Sciences et de l’Industrie (Paris), and MAMAC (Nice). JMG is the author of several books and essays including this book and *Creating Interactive 3D Actors and their Worlds* (2001), from Morgan Kaufmann Publishing.

Florent Aziosmanoff, new media artist, has a Masters in Psychosociology and Cognitive Sciences from the University of Vincennes, Paris 8, France. In 1988, he created a nonprofit art and new media association, ART3000, and today runs the Festival Premier Contact, a city-wide installation of interactive electronic art, with his brother Nils. He is currently Art

Director at the Cube in Issy-les-Moulineaux, France, where he directs the “Digital Art Atelier,” open to multimedia authors working on projects using virtual reality and real-time interactive systems (artificial intelligence and artificial life).

Miro Kirov, born in Sofia, Bulgaria in 1962, graduated with a BFA, MFA in sculpture from High School of Fine Arts and The Academy of Fine Arts in 1989. In 1990, he received a bronze medal award from the Prestigious International Bienalle in Ravenna, Italy. In 1990, he moved to New York and took part of group shows including CB’s Gallery (New York), Roxbury Gallery (Roxbury, Connecticut), and Elsa Mott Ives Gallery (New York). His solo exhibits are displayed in Hemus Gallery in Sofia, Katelbach Gallery in Hamburg, Germany, and Werkstatt Gallery in Gelsenkirchen, Germany. In 2000, Miro was hired by the New York University School of Medicine and he is currently working on his MPS at the university’s Interactive Telecommunication Program. His interests are in 3D interactive and immersive environments, 3D animation and modeling, video, and conventional fine arts.

Ken Perlin is a Professor in the Department of Computer Science at New York University. He is the Director of the Media Research Laboratory and the Co-Director of the New York University Center for Advanced Technology. His research interests include graphics, animation, and multimedia. In January 2004 he was the featured artist at the Whitney Museum of American Art. In 2002 he received the New York Mayor’s Award for Excellence in Science and Technology and the Sokol Award for Outstanding Science Faculty at New York University. In 1997 he won an Academy Award for Technical Achievement from the Academy of Motion Picture Arts and Sciences for his *noise* and *turbulence* procedural texturing techniques, which are widely used in feature films and television. In 1991 he received a Presidential Young Investigator Award from the National Science Foundation.

Dr. Perlin received his Ph.D. in Computer Science from New York University in 1986, and a B.A. in theoretical mathematics from Harvard University in 1979. He was Head of Software Development at R/GREENBERG Associates in New York from 1984 through 1987. Prior to that, from 1979 to 1984, he was the System Architect for computer generated animation at Mathematical Applications Group, Inc., Elmsford, NY, where the first feature film he worked on was *TRON*. He has served on

the Board of Directors of the New York chapter of ACM/SIGGRAPH, and currently serves on the Board of Directors of the New York Software Industry Association.

Zach Rosen is a Resident Researcher at the Interactive Telecommunications Program (ITP) at New York University. Self-taught in programming and graphics, he majored in computer science and minored in film at Brandeis University, where he pursued interests in artificial intelligence and human-computer interaction. Zach went on to get his M.P.S. from ITP where he wrote and programmed his thesis on extending the capacity of massively multiplayer online worlds using distributed client-server clusters. His recent projects include programming for the 3D re-creation of an archeological site, developing 3D shaders and other technologies for a medical grant, and designing, writing, and publishing Bluetooth software for cellular phones.

Mike Olson graduated from Harvard University in 1996. He is a former research engineer at voice recognition pioneer Dragon Systems and Vice President of Technology at Affinity Financial. He is currently pursuing a masters degree at New York University's Interactive Technology Program focusing on new interfaces for virtual environments. His primary interest lies in creatively applying novel technology in the entertainment domain, including toy design and gaming.

Eric Socolofsky (<http://transmote.com>) wanders the gray areas between architecture, interactive design, and digital and physical art. After working as an architect for a time in Chicago, he moved to Brooklyn, New York and began experimenting with interactive installations at the Interactive Telecommunications Program at New York University. He is currently further developing concepts of interactive space in his residency at Eyebeam's Production Artist Studio in Chelsea, New York. He occupies his spare time designing and programming user interfaces and games, and teaching the occasional workshop or class.

Antoine Schmitt atypically first lead a successful software designer career before becoming an active artist, exhibited internationally. For 25 years, Antoine Schmitt has been designing human-computer interaction software in various original companies in Paris and California (Act, NeXT). As an artist and programmer, Antoine Schmitt stands at the crossing of abstraction and dynamic simulation. He uses programming as a first-class material to create installations, online exhibitions, performances, and CD-ROMs.

This work has been awarded in many international festivals. As a curator, member of jury, speaker, and editor of the gratin.org portal, Antoine Schmitt explores the field of programmed art. Antoine Schmitt lives and works in Paris.

Full artist biography: www.gratin.org/as/

Software: www.as-ci.net

Noa Steimatsky is Assistant Professor of the History of Art and Film Studies at Yale University. She has just completed her book on landscapes in Italian film. Her research engages with questions of cinematic realism and modernism, poetic figuration, and documentary practices in the postwar era. She has won the Getty postdoctoral grant for her research on the face in film and, most recently, the Rome Prize for her work on Italian cinema in the 1940s.

James Tunick is a new media engineer, artist, and founder of Studio IMC, a new media design studio and artist management agency (www.StudioIMC.com). He has worked with clients such as the Museum of Modern Art PS1, Hennessy, Diesel, and others. Tunick is currently developing immersive and interactive visual displays with Studio IMC partners Tony Rizzaro and Brian Karwosky for use in retail stores, architecture, museums, and schools. In addition, he is developing interactive environments and audiovisual installations for use on stage and in architecture with Jean-Marc Gauthier, Studio IMC Principal Designer and Architect.

Among the many multimedia events Tunick has produced and organized is Interfaced Culture at Yale University, an international conference on interactive new media technology in the arts for which he received a grant with Yale professors Dr. Mathew Suttor and Dr. Kathryn Alexander in 2002. He also curated a Studio IMC show at the Chelsea Art Museum in 2004 called "Convergence: The Collision of Physical and Virtual Space in Digital Art," featuring the works of Studio IMC's top artists and engineers.

Tunick graduated from Yale University in 2003 and is currently earning a masters degree in new media at New York University's Interactive Telecommunications Program. In addition, he organized the 2nd Annual Studio IMC Expo tradeshow in New York in April, 2004, launching a Studio IMC magazine about technology, politics, and culture to be launched in 2005, and raising VC funding for the Studio IMC Research Lab & Gallery Space to be founded in New York in December 2006.

Preface

Dear J-M,

Hope your visit in Paris, our native town, is good. I recall the time, back in the late 1980s, when I visited you there in rue Lalande, and a chat over your plate of choucroute in La Coupole.

I am reading the chapters you sent me, and they make me ask myself some old questions in new ways: on optics and mental processes which are so often used as metaphors for each other; on how cinema's modes of articulation—camera movement, framing, editing—inform us about viewing habits generally, and about how those may be subverted.

I have never had any experience with VR so I was not always sure about our “object” of conversation here—I tried to imagine it in my own traditional world. What your vivid settings allow me to do is imagine it through cinema. For this I am grateful. Naturally, seeing cinema as a threshold to VR should be historically sound and pedagogically valuable. I am fascinated by the mention of Kubrick's *2001* several times in your introductory chapter. Since I am so attached to the photographic basis of cinema, I kept in mind the simple fact that *2001* is strictly *pre-digital* effects, that its production involved massive technologies and machineries and labor to achieve its astonishing images: those smooth motions, that spatial depth and absorption. I believe that, compounding the scope and enhanced resolution of a 70 mm negative, *2001* was originally designed to be screened on tilted screens that “embraced” the viewer's field of vision.

I was reminded of the material weight of all these pre-digital effects just last week. I was in Bologna where *2001* had just been screened in the Piazza Maggiore, along with such other extravagant productions such as Tati's *Playtime* (almost contemporary with the Kubrick, in fact). I was in the Cineteca film archive the following week doing my own research while they were packing the films to be shipped back to various places. And there they were: the actual, numerous, 70 mm reels of *2001*, each packed in its thick metal case with a carrying handle. I grabbed one of those precious reels and tried to pick it up, but couldn't. *It was too heavy*. This is an important lesson about that older technology, cinema, and it came to mind as I was reading your chapters.

So I am now compelled to ask: What are the material imperatives of VR? It may not claim such weight and bulk, but how *does* it claim a space? What position does the viewer, and the viewing device (itself simulated) occupy therein? How does it constitute a position, a presence, even an identity of sorts? Your tracing of a genealogy for virtual cameras in some great moments of modern cinema suggests to me that, across different media, and in both theory and practice, the two of us coming from different fields may be exploring similar terrains. I know that these are also the concerns that haunt our most adventurous students. What does it mean that a camera intrudes upon a scene, that its presence confronts our anthropomorphic habits of looking and sensing our environment, confronting as well our emotional responses, our relationships with people and objects and places?

Reproducing with new media the traditional forms and values of mainstream cinema may be a good lesson but, reading your account of the positioning of producer and consumer, author and viewer in VR suggests that surely there is something new, possibilities yet to be imagined and pursued in radically new ways through the limitless choices opened up in VR. For “choices” cannot remain a mechanical navigation akin to those maddening telephone menus that end up impoverishing experience. We seek rich and compelling relationships in every sense—with the natural and the built environment, with things, with each other, and with earlier instances of experience, with time. To my cinematic sensibility, these ideas emerge in your evocation of the “gaps” that open up in the visible arena of Hitchcock’s *Rear Window*, in the obstructions of the wild environment of Antonioni’s *L’avventura*. How would such a compelling, difficult space—a space of play, desire, mystery, and anxiety for the mind as much as for the eye—translate to VR? What would it mean in that virtual domain that (as Antonioni observed) people disappear every time they leave the room? Perhaps in that virtual *there* this would be completely reasonable!

Shall we look at the island sequence together when we meet again?

Yours,

Noa

late July 2004, New York

Noa Steimatsky teaches film studies in the Department of the History of Art at Yale University.

Introduction

I have found ways to express myself as a writer, moviemaker, photographer, and architect but still felt the need to communicate ideas that did not fit into any of these domains. New possibilities for expression emerge in the design of virtual spaces. Designing virtual spaces helps me convey ideas in ways that cannot be expressed the same way in writing, movies, photographs, architecture or other visual art. Surrealist artists from the 1920s (Man Ray, Marcel Duchamp, Louis Bunuel) felt that movies could tackle situations or emotions that could not be depicted in writing or in the traditional visual arts of their times. For similar reasons, topics covered in this book stretch beyond the strict domain of virtual spaces. They relate to larger concepts like the future of cinema, the place of virtual spaces in tangible public spaces, defining new experiences for the viewer of a virtual space, or developing new types of associations between several media that may involve both the virtual and real. I hope that this book will help you to look at virtual spaces as an immense territory for experimentation where you can build, explore, and play more easily and faster than in the physical world.

Virtual sets are redefining the way film directors, dancers, scientists, medical researchers, architects, TV producers, and web designers can develop simulations of real world situations. Examples of immersive virtual sets described in this book range from the 3D pre-visualization of a movie scene prior to shooting on location, to a virtual visit to an agora of the antique city of Aphrodisias, Turkey. Applications of virtual sets I cover range from interactive TV games to information systems created for decision makers.

Sections of this book cover the creation of real-time interactions between an audience and a virtual actor using sensors and artificial intelligence. I explain how a viewer can interact with virtual sets using simple inputs such as live-video, gestures, or sound, as well as up-to-date technologies like cellular phones.

“The beauty of nature lies in detail; the message, in generality. Optimal appreciation demands both, and I know no better tactic than the illustration of exciting principals by well-chosen particulars.” (From Stephen Jay Gould. *Wonderful Life: The Burgess Shale and the Nature of History*. New York: W. W. Norton & Company, 1989.)

Gould's ideas about how to describe the living environment of some of our planet's first animals can be a source of inspiration for someone who attempts to design virtual worlds. Like in Gould's first sentence, the designer's special attention to details conveys a sense of beauty to the viewer; but the vision of virtual spaces needs to be much broader.

This book addresses the creation of simple 3D interactive environments where some elements of virtual spaces such as interactive textures, virtual cameras, kinematics, real-time physics, and self-determined virtual actors can be found. Each chapter covers one aspect of interactive 3D, illustrated by a complete tutorial. I give in-depth explanations of reusable building blocks and modifiers that can be applied to 3D objects, cameras, lights, and animated characters. More than an introduction to the fascinating world of 3D, this book also offers insight into how to design real-time special effects for movies, TV broadcasts, interactive games, or even 3D games. Examples will utilize Virtools, Maya, and Lightwave software to show how to design and program virtual sets.

Two main directions of this book are to create interactivity and a sense of presence in virtual spaces. The place of the viewer is a key element of the design of a virtual space. The viewer is in motion inside a physical space where the expected notion of facing a screen tends to disappear. This book shows installations where viewers are invited to walk around installations where 3D content is presented on screens extending in multiple directions of a space, challenging the reactivity of the virtual space around them. The design of virtual cameras with artificial intelligence will also be addressed in order to create relationships between a virtual camera and the context of a scene.

THE ORGANIZATION OF THE BOOK

This book is organized like a “cookbook for interactive 3D,” bringing the reader through a personal process. Each chapter introduces specific examples of virtual sets illustrated with hand-drawn sketches. The tutorials present step-by-step creation of virtual sets starting from early storyboards, notes, and sketches and evolving into fully working prototypes. This “cookbook” approach will help readers understand how they can better apply and then market their own skills. The companion CD-ROM includes files for the tutorials and a full trial—PC version of Virtools 3.0. You can play the examples inside the Internet Explorer window for Mac or PC. You can also recreate the tutorials in Virtools 3.0.

For more advanced readers, the book presents several applications of real-time physics that can greatly enhance the immersive experience in a virtual world. The book includes a collection of behaviors illustrating how to simulate natural phenomena such as virtual wind, fire, pyrotechnics, smoke, clothing, ropes, and hard and soft body collision.

- **Basic entries** (or keywords) for this book include *3D basic kit, animation basics, gravity, floors and stairs, live video, virtual cameras, interactive 3D lighting, communication environment, interactive character animation, interactive kinematics, broadcasting messages, and event-driven animations*.
- **Typical step-by-step tutorials** found in this book cover collision detection, virtual cameras inspired from movies, virtual characters and bots using path finding and terrain analysis, simulation of a crowd in motion, applications of virtual sets for movie sets, and artificial intelligence and gameplay for decision making.
- **More advanced entries** for this book include a virtual archeology project, architectural simulations, medical simulations, interactive kiosks, immersive displays in a museum, and urban installations. The book shows examples of virtual spaces created for research and interdisciplinary projects helping to communicate ideas to a group of diverse and highly creative people. These examples of virtual spaces were created in order to think about a problem in many different ways. The book covers the making of installations inside a museum gallery or an urban space. These examples show how viewers can break away from the traditional conventions of viewing art in a museum.

THE CONTENT OF THE CHAPTERS

Each of the following chapters covers a domain of virtual spaces.

- **Chapter 1** lays out the convergence of several artistic factors present in virtual worlds.
- **Chapter 2** presents the basic 3D kit with a tutorial on modeling and animation in Maya and the particular setups to export 3D content to Virtools.
- **Chapter 3** documents kinematics and all aspects of interactive motion. Topics covered are related to imitation of motion, lighting and physics,

and the early steps of imitation of nature in virtual spaces where responses to situations are not predefined, but created on the fly.

- **Chapter 4** develops interactive textures.
- **Chapter 5** develops interactive path techniques presented both as key elements of storytelling and as examples of increasingly complex interactivity.
- **Chapters 6 and 7** cover virtual cameras with behaviors modeled on real world characters.
- **Chapter 8** probes the viewer's experience of virtual reality becoming an activity that can rival with some of the best cinematic experiences.

A BOOK ABOUT THE PROCESS OF CREATING VIRTUAL SPACES

The creative process and the production process are presented side by side through text, sketches of virtual worlds, and drawings created during the course of various projects. The emphasis given to the process of collaborative work helps the reader to understand that many different skills can be involved. Several interactive projects are documented in order to fully illustrate the connections between designing assets, programming digital art, and the viewer's experience. I hope that this effort of documenting the work in progress will help you to go beyond creative thresholds of artistic expression and invention.

The goal of a virtual space designer has become more and more about the imitation of living systems so other people can identify, evaluate, play, and create. Mapping internal states, mental desires, and perceptions seems to be the final frontier of virtual spaces and raises exciting issues of representation. Can we explain how to represent our dreams? How can the autonomous agents that you created represent their dreams? Whose dreams are they—yours or theirs?

I hope that you become more curious about your own ideas while reading this book and that you will enjoy discovering the making of virtual spaces.

CHAPTER 1

Emergence of Virtual Spaces

1 EMERGENCE

People living at the end of the nineteenth century saw the first movies. The Pathé brothers, owners of fun fair attractions and movie producers and distributors, presented movies directed by Melies to small audiences under a tent built next to other attractions such as magicians, fire throwers, and sword swallowers. The movie theater found its audience and its own specific space several decades after the first screenings of the Lumière brothers, in a fancy restaurant called the Café de Paris. The layout of the movie theater, a space designed for a collective viewing experience, remains unchanged still today.

At the end of the twentieth century, online three-dimensional (3D) games reached audiences of millions of people sharing the same virtual space through a multiplayer online experience. The convergence of networking, the internet, and interactive 3D worlds changed a gaming experience based on one desktop into a virtual space experience played by an unlimited number of people.

Comparing the evolution of virtual spaces and the evolution of other media helps us understand the emergence of new types of viewer's experience and of new audiences through time. Trying to define an audience and a viewer's experience for virtual spaces seems to be a priority for a young medium with a direct appeal to large audiences. This chapter tries to answer several questions about virtual spaces and the future of the viewer's experience.

2 DISCUSSION ABOUT VIRTUAL SPACES

This chapter takes you through a virtual conversation that takes place in a group that includes designers, producers, developers, and 3D artists.

More detailed information on the following participants can be found in Biographies.

Ken Perlin is a professor in the Department of Computer Science at New York University. He is the director of the Media Research Laboratory and the co-director of the NYU Center for Advanced Technology. His research interests include graphics, animation, and multimedia. Ken won an Academy Award for Technical Achievement from the Academy of Motion Picture Arts and Sciences for his *noise* and *turbulence* procedural texturing techniques, which are widely used in feature films and television.

Miro Kirov is a sculptor and a 3D artist from Bulgaria who works and lives in New York. For the past 4 years Miro has been creating a virtual human body for Advanced Educational Systems at New York University. Miro and I collaborate on the Dynamic Virtual Patient project and on virtual space installations with James Tunick and Studio IMC.

Zach Rosen is a designer and developer who lives and works in New York. Zach is a researcher at the Interactive Telecommunications Program at New York University, where he graduated. Zach and I collaborate on several virtual reality projects funded by New York University. Related projects illustrated in this book include the Aphrodisias project and the Dynamic Virtual Patient project.

Florent Aziosmanoff studied psychosociology and cognitive sciences before becoming artistic director at the Cube in Issy-les-Moulineaux, France. He created the association ART3000 and the Festival Premier Contact with his brother Nils and the team at the Cube. Francois directs the “Atelier de creation” at the Cube, a workshop for artists and authors creating virtual reality projects and real-time interactive systems. Artists and authors can develop projects from scratch using decision-making techniques including artificial intelligence and artificial life.

2.1 Let's Start the Discussion

What are you looking for when entering a virtual space?

Ken

When I enter a virtual space, the most important thing that I look for is a feeling that I'm entering a world that will touch me emotionally, that I can immerse myself in. It's a very childlike feeling of wonder when it works.

Miro

I am looking first for the ground under my feet. If the world is a simulation, then the virtual environment is our reality. Knowing that the world is a three-dimensional abstract expression floating in space is just another option.

Zach

When entering a virtual space, my first goal is to learn the methods of manipulating the space. This can take the form of locomotion, cursor navigation, sound manipulation, etc. During this brief orientation, I am looking for visual or auditory feedback to let me know that my actions are causing a reaction. Now that I know the tools that are available, the second step is to explore these methods to determine their capabilities. If I know how to make the character walk forward, can I get him to walk stairs? If I whistle to change the color of the screen, what happens when I whistle louder or softer, higher or lower?

Once I am comfortable communicating with the space, I can begin discovering what the purpose of the world is. As essential as instant feedback was to help orientate me with the controls, I am now looking for reference points or clues to tell me where to go or what to do. Is there a location I must discover or a mission I must accomplish? Am I here only as an observer or am I an active participant? At this point I am in the hands of the developers to guide me toward their intended purpose for the space.

What is the importance of the viewer in the design of virtual spaces?**Ken**

The viewer is the most important thing in the design of virtual spaces, just as the reader is the most important thing in the design of a novel.

Florent

We can be sure of one thing: the viewer alone cannot “turn” any reality into a virtual reality environment without the input of the author. Let’s take the example of a visitor walking inside the park surrounding the Chateau of Versailles, a seventeenth century garden designed and created by Le Notre. The viewer is immersed inside a landscaping project inspired by a certain vision of the world at the time of King Louis the XIV. Although everyone

can browse freely and at his or her own will in the alleys of the park, each visitor is constantly reminded of the rules created by Le Notre. For example, the timing of walks and transitions between various sections of the garden are rigorously designed. The visitor can feel the dramatic perspective of the space starting from the castle, going over the “green carpet” and the Grand Canal. The view of the horizon is blocked by a row of poplars from Italy and projected toward the sky. The visitor, immersed inside this grandiose and calm space, can see thousands of visitors following their activities quietly. One can feel how the layout of a space suggests a world united and pacified. This is certainly the world that Le Notre, the author, intended to design.

Zach

When designing a virtual space, every decision must incorporate a consideration for the resulting effect on the user’s experience. While it may be interesting to explore visual phenomena or push technical boundaries, the reaction of the user should remain a primary concern. Successful interactive installations entice the user to participate by using visual clues to suggest that something will happen if the user touches the mouse, screen, etc. If a virtual space is too active when there is no user input, viewers will take less interest in interacting and become passive observers. A space that understands what the user is feeling will help to orientate the user and improve his or her understanding of the purpose of the space.

Miro

The importance of the viewer is essential for virtual spaces. The role of the viewer can be passive, observant, active, or interactive. The whole purpose of virtual space design is to achieve an immersive and interactive experience between the viewer and the world.

Can you describe a viewer’s experience—situation or emotion—that you find specific to a virtual space? Can you compare the experience of a viewer inside a virtual space with an interactive moviegoer’s experience?

Ken

I think that virtual reality spaces are very good for communicating awe and mystery, if they are properly done. I have never seen an emotionally effective interactive movie, so it’s hard to compare the two.

Miro

Our mind is a funny thing. It is like sponge. It absorbs everything. I had this strange experience of being totally immersed in some 3D world and vice versa. After long hours of 3D game playing, the experience of elusiveness of the surrounding world is a kind of inversion of reality that can be a dangerous thing!

The moviegoer can immerse into the story, the drama, but has no control over it. He or she is a passive contemplator of it. It is very linear in time. The virtual space viewer has more of a choice over actions and what to see. It is very much like life. We are in a certain situation and we have to make a choice with its consequences.

Zach

If there are no apparent guidelines or goals, the ideas of the developer will not be successfully communicated to the audience. The most common reaction that I see with viewers of virtual spaces is confusion. Unlike film or television, virtual spaces are flexible at being active or passive creations. The message of a virtual space can be a lost process when viewers get confused. There is a very sharp learning curve that takes place when someone decides to participate in an interactive installation.

Florent

We can be tempted to look at virtual reality the same way we look at movies. The viewer is in both cases taken inside an immersive sight and sound system, with the addition of a mouse or keyboard in the case of a virtual reality environment. But we can grasp major differences between virtual reality and movies when looking at the way real-time systems change the way to deliver content and the structure of the content being delivered. Differences may be even stronger than between theater and cinema. In virtual reality, the viewer's experience goes beyond sequential storytelling. Let's take again the example of the garden surrounding the Chateau of Versailles. The viewer's experience of a virtual reality tour of the garden may be very different than watching a movie about the park of the Chateau of Versailles. In one case, moviegoers follow a point of view that can't be changed; in the other case, viewers are free to choose their viewpoint and the location of the camera and to create their own editing, etc. I am not sure if traditional movie editing can be used the same way in virtual reality.

The way content is delivered in movies and in virtual reality is so different that I am not even sure that they can be compared. There may be a way to reuse some formal experiences borrowed from movies—for example, framing, moving the camera, and mastering the tempo of a scene.

Can suspension of disbelief be part of the viewer's experience in virtual spaces? Is this something that you are looking for as a visitor, as a designer?

Ken

Yes. In fact, I think it is all about suspension of disbelief. That is the factor that allows us to make extremely nonlinear choices in design (focusing on some things and ignoring others), much as a filmmaker might focus on only certain characters and leave others sketchy.

Miro

It depends on if your virtual space is mimicking the sense of reality and perspective, if the meaning of the word “space” is perceived as a tangible form. The Cartesian coordinate system usually used for virtual environments should not necessarily be a way to present things from our imagination, but it can be used as an aid.

How can people learn from virtual spaces?

Miro

Well, virtual spaces can enhance the way we see things and memorize valuable information on the reality of things. We still see the world as a flat pancake. Only at some point of the coast, looking at the sea, can we see that the world is round on the horizon and yet we believe it's round from our knowledge. In this context, we would be able to experience different kinds of perspectives of representation with the help of the technology—for example, we could perceive a patch of grass from the point of view of an insect.

Zach

It is essential to remember that realism and believability are two separate entities. Designing a realistic space will lock you into a constant

comparison between your work and its real world counterpart. It is a thankless struggle because the real world will always seem more “real.” Rather than focusing on realism, bring the viewer into a new realm. Do not be afraid to let them know that this is a different type of reality where some things may be recognizable and some things may seem disturbingly different. As long as you are consistent, the audience will believe every piece of your new world.

As a designer of virtual spaces, you are blessed with an audience that expects to be transported to a new reality. Treat your viewers as you might treat an out-of-town guest: you may want to show them how to get around or what is available for them to see or do. Your space can be as close to or as far from the real world as you decide and your audience will follow you there, but if you leave them without any reference point, any rules, or a motive, they will feel lost and retreat from your space.

Is it possible to use some linear content to tell a story inside a virtual space?

Florent

The question is open. I currently design *Le temps de l' amour*, a virtual reality fiction that uses linear content. The viewer can jump in the story but can't control the delivery of the content. The viewer can only control his or her viewpoint on the story. The viewer is placed in a situation similar to Wim Wenders' angels in *Wings of Desire*. My contribution to this project is to give full access to all the levels of the story for the viewer, including present, past, and future. I am to give not only an unbiased report about what happened inside a specific scene but also the subjective, conscious, and subconscious viewpoints of a character in the scene. This open system lets you change your point of view on the story rather than changing the elements of the story. Since my original idea was to mimic a movie, this experience gave me the opportunity to think about how to create stories for movies by allowing the viewer to have total freedom to choose a viewpoint.

In movies, the director chooses a point of view for you. For example, the director chooses the main character or two main characters if there is a duo. Other secondary characters—who tell us other ways to see the story—help to structure, to contradict, or to embellish the main character. Even

movies built around the opposition between two protagonists (such as a man and a woman or a cop and an outlaw) need to emphasize the point of view of one dominant character. This constraint comes from the limited duration of a film, which is about 2 hours. This is just enough time to present one way of looking at the story; using the unit of the sequence gives a way for the viewer to measure time, emotion, and cognition. We know that the cinematographic language is partly based on the ability of the viewer to project himself or herself on the main character. It seems impossible to change the main character, the viewer's referential, during the time of a sequence.

Are you interested in the utopian dimension of virtual spaces? Do you find a place for ambiguity, unexpected events, or failure in virtual spaces?

Ken

I don't see how you could have a utopia without ambiguity or unexpected events or failure. After all, those qualities are a necessary part of being human—without them we are not in a utopia but rather in a sterile lifeless place.

Miro

No, I do not believe in a utopian dimension of virtual spaces. The surprise event is crucial in this type of environment. It can be a great educational tool to teach people to see and react to. Unlike life, in virtual spaces failures can be fixed, conditions restored, resources regenerated. Virtual worlds are more forgiving in that sense.

Zach

The possibilities for expression in virtual spaces are truly endless. It is a medium that can combine nearly every other type of media and contains all of the flexibility and power therein. Utopias are one possibility, but dystopias are also effective as political or societal commentary or explorations of phobias. Ambiguity and discontinuity can also be used as effective tools as long as they are used intelligently and do not confuse the audience so much that they lose interest.

Is it possible to create storytelling systems with autonomous characters in virtual reality?

Florent

In 2001, I created an adaptation of the tale of *Little Red Riding Hood* with three autonomous robots.¹ The robots were small animated dogs with 20 motors, several sensors, cameras, and microphones. These truly autonomous machines could manage their environment and could acquire complex behaviors similar to artificial life and artificial intelligence. I was working on the simple story of *Little Red Riding Hood* in which the little girl, the wolf, and the hunter are set up inside a repetitive system of relationships. I was interested in the moral, social, and psychoanalytic aspects of the tale that can be found in the study done by Bruno Bettelheim.²

The wolf is looking for Little Red Riding Hood, who listens anxiously until the hunter brings the situation to an end. After the encounter, each actor is reset to walk around until a new set of circumstances brings the actors together again. The play is designed to repeat itself indefinitely with various versions of the same story line. The robots were created to play among people in the streets. They were designed to respond to an environment that could change according to the context—for example, interactions with viewers could interfere with the story line. Viewers could help to end the story, to protect Little Red Riding Hood, or to create new situations. The wolf looking for the color red could be misled sometimes by a kid's red shoes or a person's red handbag.

Creating this piece followed the same constraints that we apply to virtual actors inside virtual reality; the tools are also very similar. This piece required tweaking parameters for various behaviors and creating responses to external stimulations while controlling the equilibrium of the whole system. For example, if Little Red Riding Hood walks too fast, the wolf may never catch up with her. The dangerous wolf becomes a pathetic character, and the story line is completely changed.

¹ Bettelheim, B. (1976) *Psychanalyse des contes de fées—The Uses of Enchantment*. Paris: R. Laffont.

² Sony's Aibo robots created for 1erContact festival, organized by ART3000—Le Cube, Issy-les-Moulineaux (France). Urban installations of digital art are presented throughout the city.

I was very surprised to see how the play performed remarkably well on the functional level, on the storytelling level, and in relationship with the audience. I noticed that the audience did not want to interact directly with the piece. Children wanted to have a specific relationship with one of the characters and specifically with Little Red Riding Hood. Some of them tried to create a personal relationship with the character of their choice, trying to protect it from other actors or from other visitors. Watching these behaviors made me understand the kind of new space I was looking for.

Which references, books, movies, music, and examples of other topics would you recommend to the reader?

Ken

Turn off the lights, get a good projector with a good sound system, and go back and watch *2001: A Space Odyssey*. Think about the way Kubrick plays with time to create mystery, the way the film raises questions in your mind just by juxtaposing virtual spaces that are very different in our emotional and cultural landscape.

Miro

Alice in Wonderland, *The Little Prince*, Kafka, Joseph Campbell's lectures. Escher always fascinated me, Calder's sculptures, Van Gogh's skies. Some of the performances of Cirque du Soleil, Aida at the Met, Frank Lloyd Wright's Guggenheim museum building. For films, Fritz Lang's *Metropolis* is a classic; Terry Gilliam's *Brazil* too. Kubrick's *2001: A Space Odyssey* is not taking place in 2004. I find it fascinating to live through times that others dreamt about in the past. Spielbergs' futuristic experiments with today's cinematic story telling are interesting too.

In *Microcosmos*, the movie, a patch of grass is shown from the point of view of an insect. What a wonderful example of how to see the world in a different perspective.

2.2 Notes on the Discussion

I added the following notes after "listening" to the discussion.

Designing virtual spaces is some kind of a reduction of the cinematographic art to its most essential elements, a trip back to the origins of capturing motion and the invention of the first cameras.

Virtual spaces are mostly designed like a set of trade-offs and alliances between the sensuality of the virtual body, the presence of a virtual character, the presence of the viewer, and the spatial arrangement of machines producing images faster and in more seducing ways.

Designing virtual spaces and making movies can share similar goals, with each one following a different process leading to these goals:

- 1** Finding new ways to distribute camera locations in space
- 2** Focusing the viewer's attention on significant details
- 3** Walking through terrains held together by a story and creating connections, bridges between the ring enclosing the spaces of a story and the rest of the world
- 4** Moving forward in all possible directions inside a multidimensional world

Magicians use psychology to distract the audience from the trick being performed, and they use technological skills to perform their tricks. David Copperfield's mastery of technology allows him to execute parts of a trick that remain unseen by the audience. The suspension of disbelief required by the viewer during a magic trick is short compared to the duration of a movie. Putting together a puzzle of psychology and technology has always been a central element of fun fair attractions and circuses, from designing a roller coaster to displaying optical illusions. Movies are based on a similar illusion of perception. Moviegoers are under the impression that they view movement instead of single picture frames. Moviegoers perceive movement as the result of an alliance between a psychological factor, believing in an optical illusion, and a technological factor, making that illusion permanent over time.

CHAPTER 2

The Basic 3D Kit

1 THE ROADMAP

This chapter is an introduction to basic 3D modeling and animation in Maya and Virtools. “Basic 3D Kit” means that you will learn a selection of creative tools that will get you up and running quickly using Maya. This chapter, designed to be fun and creative, will hopefully make you anxious to explore this amazing software.

The following tutorials, created in collaboration with Miro Kirov, show how to use Maya and Virtools for creating interactive models and animated characters. We hope that you will enjoy the process of producing 3D interactive content.

The first tutorial is a step-by-step introduction to modeling and animating Mr. Cyclop, an interactive character in Maya. The second tutorial shows how to create trees and grass in Maya using 3D paint tools and how to set up Mr. Cyclop inside the forest in Virtools. The last part of the tutorial shows how to add scripts to the character in Virtools.

2 THE MAKING OF MR. CYCLOP, AN INTERACTIVE CHARACTER IN MAYA



Mr. Cyclop is a one-eyed mythological creature with a good and charming temperament. Mr. Cyclop is a goofy creature who enjoys playing inside a lush forest.

This tutorial covers step-by-step modeling, texturing, and animation of an interactive character, using two 3D applications: Maya and Virtools.

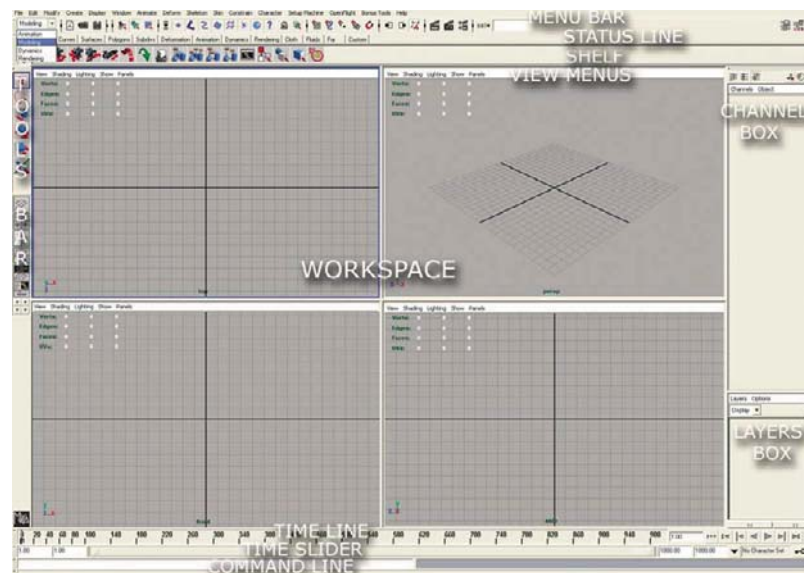
Maya will be used to build and animate the 3D content. Virtools will be used to add behaviors, including scripting an interactive environment using a keyboard, a mouse, or a game controller.

This tutorial shows how to create a goofy Mr. Cyclop using Subdivision Primitives, how to add textures, and how to animate the Cyclop's walk using skeletal structure and Inverse Kinematics systems.

2.1 Tour of Maya's Interface

Let's take a tour of the Maya interface.

- Open the Maya application, and take a tour of the interface.
- Maya, like other 3D applications, uses several modules called Modeling, Animation, Dynamics, and Rendering.
- From top to bottom, you can find the Menu bar, the Status Line, and the Shelf.
- The Workspace includes top, side, front, and perspective views.
- The mini Tools bar is located on the left side of the Workspace.
- The Channel box is on the right side of the Workspace.
- The Layers box is under the Channel box.
- In the lower part of the screen, you can find the Time Line, the Time Slider, and the Command Line.



Maya's interface.

Let's review the row of tools represented with icons located below the top menu.

The tools change according to the module selected in the Status Line box. Click on the box located on the left in the Status Line to see the different modules. We will use Modeling and Animation for this chapter.

The first group of tools found in the menu bar includes buttons for the following commands: Create New Scene, Open a Scene, and Save the Scene.

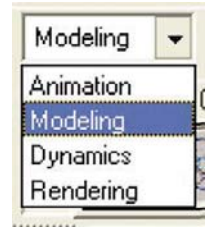
The second group of items includes buttons for selection: Selection by Hierarchy, Selection by Object, and Selection by Components.

The third group of items includes buttons for selecting different components: Vertices, Lines, Polygons, and Curves.

The fourth group of items includes buttons for snapping tools: Snap to a Grid, Snap to a Curve, and Snap to a Surface.

The last group of items includes shortcut tools for rendering: Render, IPR Render, and Render Globals.

The Shelf can be customized to store your most frequently used tools.



The tools change according to the module selected in the Status Line box.

To customize the shelf:

Click on a tool in the menu bar and press Shift and Control simultaneously. You will see an icon of the selected tool added to the Shelf.

The Workspace is the place to preview your 3D content. You can customize the Workspace according to the type of views and rendering mode including shading, texturing, or wireframe mode. You can toggle between the perspective view and the four (top, front, side, perspective) views by pressing on the space bar. Each of the views has its own menu bar including View, Shading, Lighting, Show, and Panels.

To navigate in the perspective view window use the following commands:

- To rotate, use the alt key and the left mouse button.
- To pan, use the alt key and the middle mouse button.
- To zoom, use the right mouse button.

The Tool bar, located on the left side of the Workspace, includes the following tools, starting from top to bottom: Select, Lasso Select, Move,

Rotate, Scale, Manipulator, and Current, which displays the tool that you are currently using. The Layout bar with icons for different views of the Workspace can be found under the Tools section.

The Channel box, located on the right side of the Workspace, contains information about 3D models selected in the Workspace and current transformations applied to the models. The Layer box contains information about the layers created for 3D objects and lets you work on each 3D object without affecting the others.

The Time Line displays the key frame numbers. The Animation Controls and the Time Slider help you browse through the Time Line.

The Command Line for Maya's scripting language (MEL) commands lets you script transformations of the 3D content.

The Help Line is located below the Command Line.

After exploring the basic elements of the Maya's Interface, you can start building your character. You will use a fast and accurate way to model a character called Subdivision Surfaces. This modeling technique allows the computer to calculate shapes as polygonal surfaces and to display a subdivided smooth approximation of surfaces. After the modeling phase, we will convert the model to a polygonal mesh. Let's start modeling.

2.2 Modeling

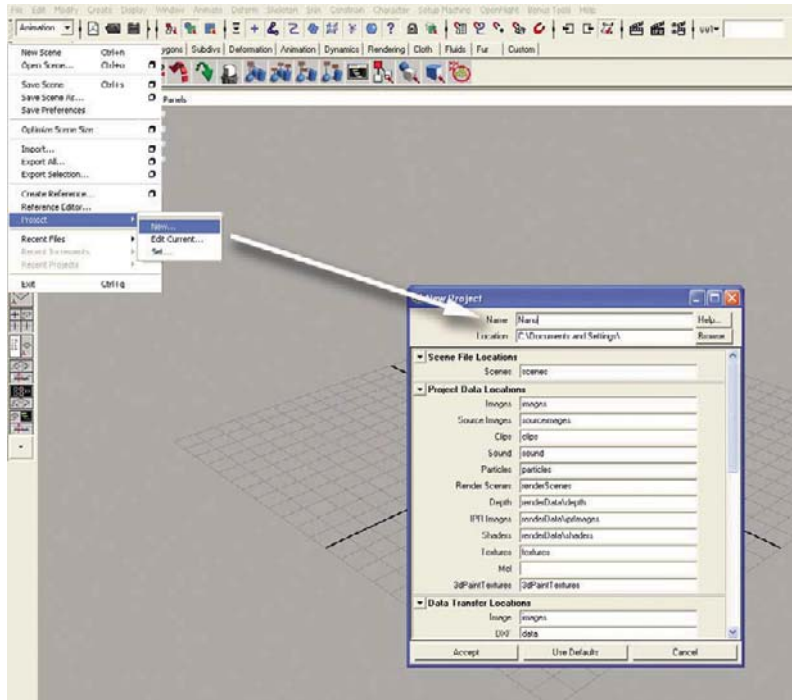
Start your project by creating a project folder and its subfolders, where your content will be saved.

To generate a new project folder:

Go to the top menu, select, File > Project > New. In the dialog window specify a name for your project, choose the location where it will be saved, and click on Use Defaults. Click Accept to close the window.

To start creating the character, choose the modeling module. Go to the top menu, and select Create > Subdiv Primitives > Sphere.

Subdivision Surfaces has two modes: the PolygonProxy Mode, in which the shape can be manipulated as a polygonal mesh, and the Standard Mode, used for fine details.



Start your project by creating a project folder and its subfolders, where your content will be saved.

We will use the PolygonProxy Mode for this tutorial.

Go to the top menu, and select Subdiv Surfaces > PolygonProxy Mode. The workspace displays a wireframe cube with its smooth approximation.

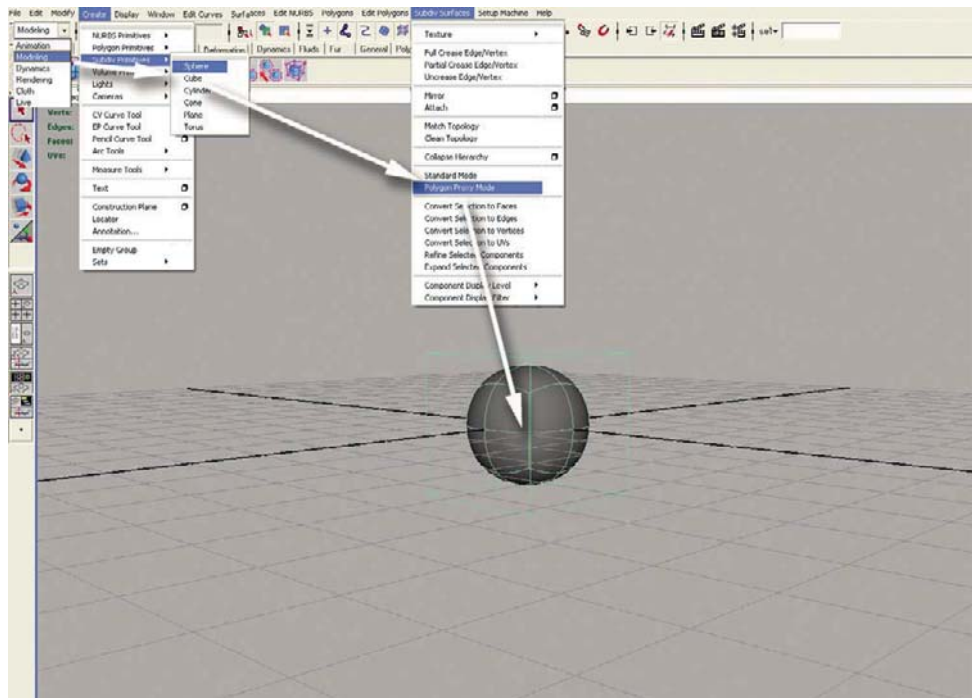
Press key 5 to display the sphere in the shaded mode.

Press key 3 to increase its smoothness.

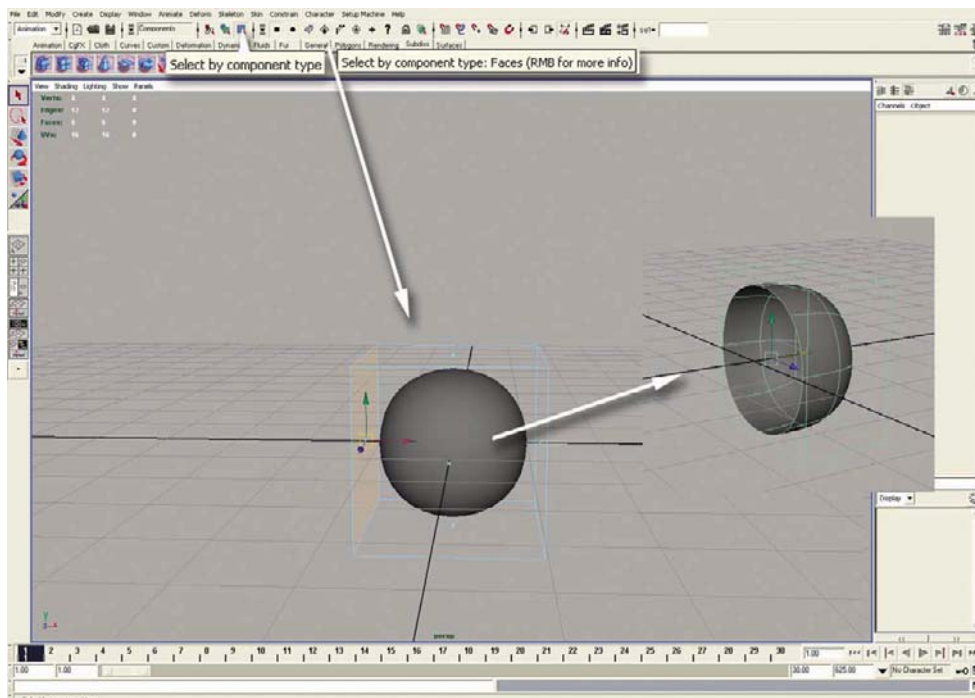
Now let's select the cube by its components: vertex, line, and polygon.

In the Status Line click on the Select by Components button, then click on the Face button. The color of the cube changes to blue and a handle appears on each of the sides. Lines of bounding boxes are visible on the borders of the polygons.

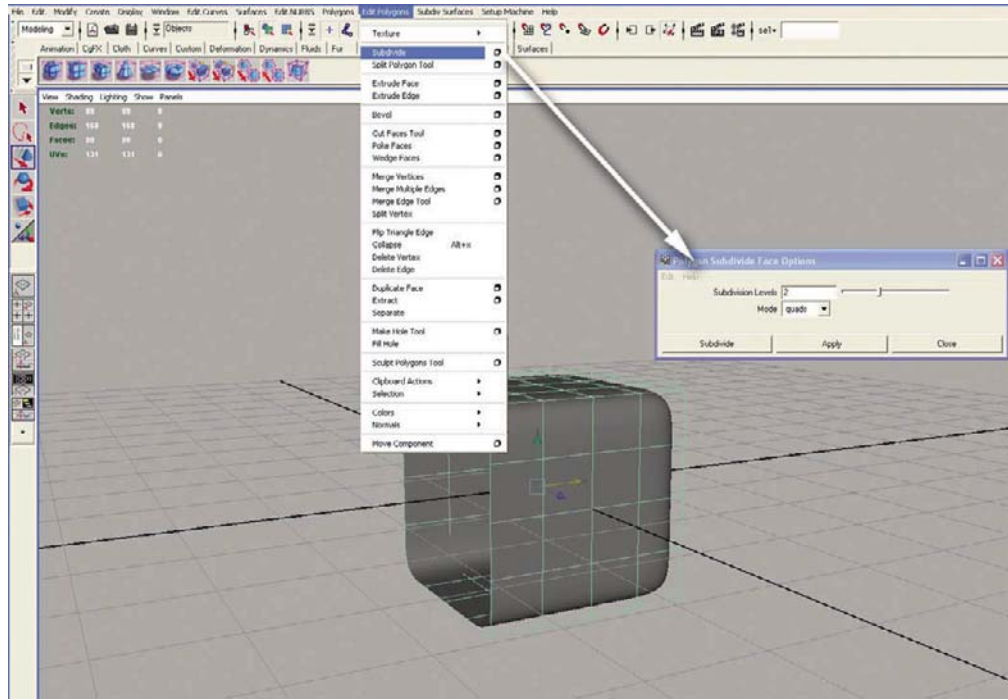
To select the left side of the cube, click on the blue handle located on the left side of the cube. Press the Delete key. The 3D object looks like one-half of a sphere.



To start modeling, choose the modeling module. Go to Create > Subdiv Primitives > Sphere. We will use the PolygonProxy Mode for this tutorial.



To select the left side of the cube, click on the blue handle located on the left side of the cube. Press the Delete key. The cube now looks like one half of a sphere.



You can subdivide the polygons of the cube. The edges of the polygons turn green.

You can subdivide the polygons of the cube by selecting the Object Mode from the Status Line or by pressing the F8 key. The edges of the polygons turn green.

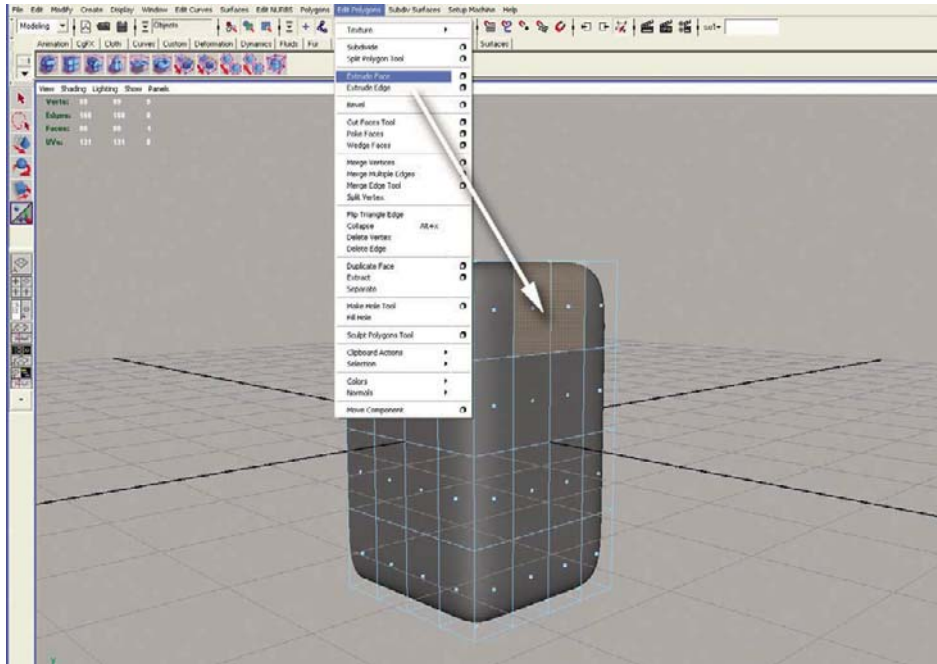
Go to Edit Polygons > Subdivide > Options. The Polygon Subdivide Face Options dialog window contains options for the Subdivide tools. Select subdivision level = 2 and click on Subdivide. Your model is similar to the one in the following illustration. First, you will be modeling only one side of the character. Later, you will mirror the other side of the 3D model.

This soft cube represents one half of the character's torso. You can use Move and Scale from the Tool bar to reshape the torso.

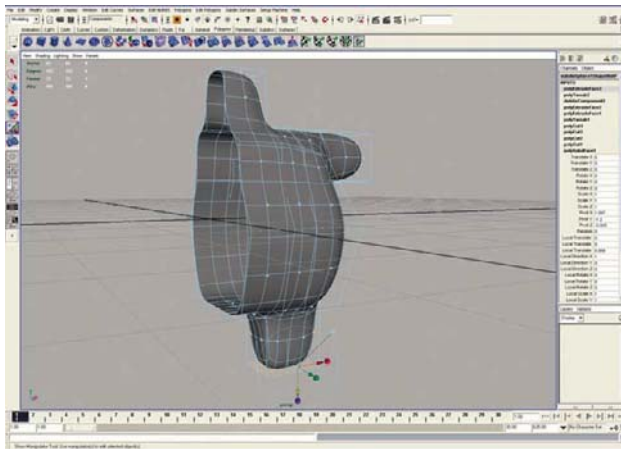
Go to the top menu bar, select, Polygon > Tools Options. Ensure Keep Faces Together is turned on.

In the Status Line, choose the Components Face mode. You can also press the F11 key. Select two polygons located on the right side.

Go to the top menu, and select Edit Polygon > Extrude Face.



Select two polygons located on the right side and extrude the faces.



Click and drag the yellow arrow from the Manipulator tool, perpendicular to the selected polygons. You will notice that the smooth surface is changing shape locally.

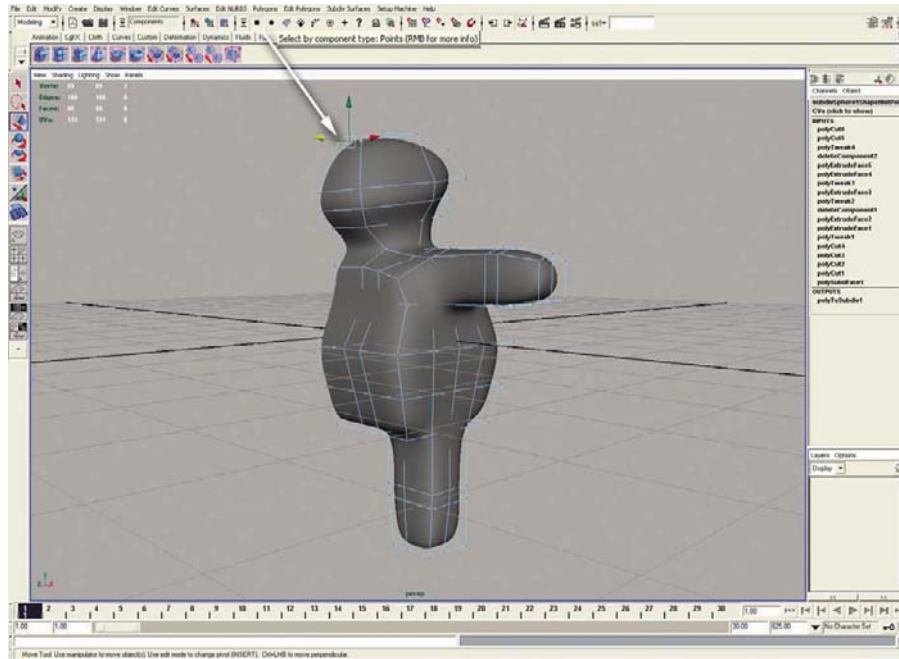
You just created a new polygon that remains connected with the rest of the character. The Manipulator tool is automatically activated. Click and drag the yellow arrow, perpendicular to the selected polygons. You will notice that the smooth surface is changing shape locally. You began to create a new arm for your Cyclop.

Repeat the same operations for the left leg and the neck.

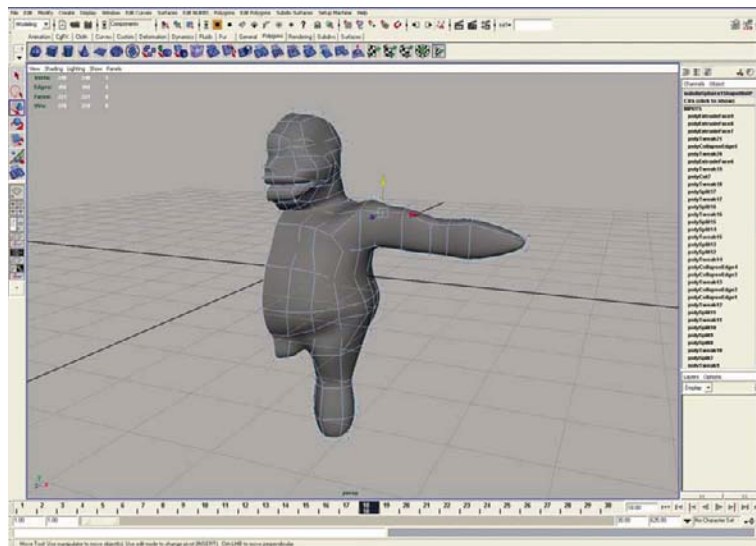
Let's play with selecting other components such as lines and vertices. You can select lines and vertices either from the icons of the Status Line or by pressing the F10 or F11 keys.

Let's model the character's limbs and face from the basic shape that you created.

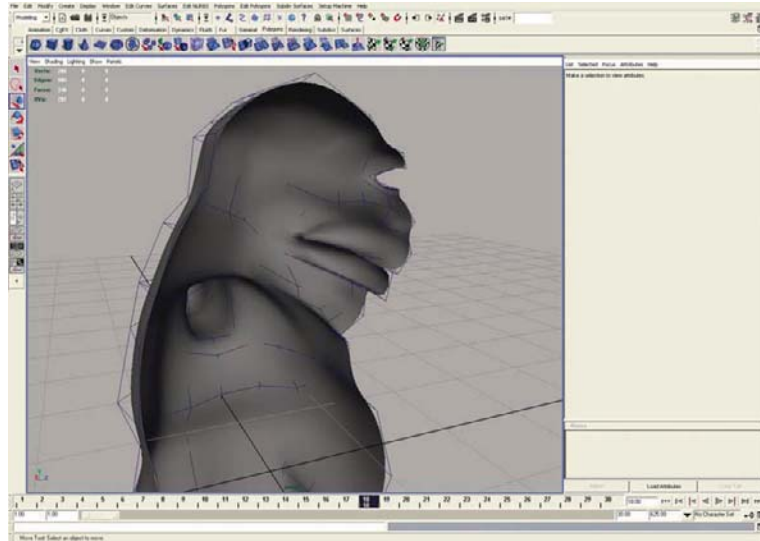
Let's work inside the model to define the mouth and the eye socket.



You can model the character by moving lines and vertices.



Modeling the character's limbs and face.



Side view of half of the character.

Go to the top menu, and select Edit Polygons > Extrude Face. Select the Extrude Face tool or the Split Polygon tool to add more details.

To split a polygon, select Edit Polygons > Split Polygon Tool. Select the Split Polygon tool, and click and drag on the desired lines surrounding the polygon. This tool will let you create small details such as the eyes, the nose, and the fingers.

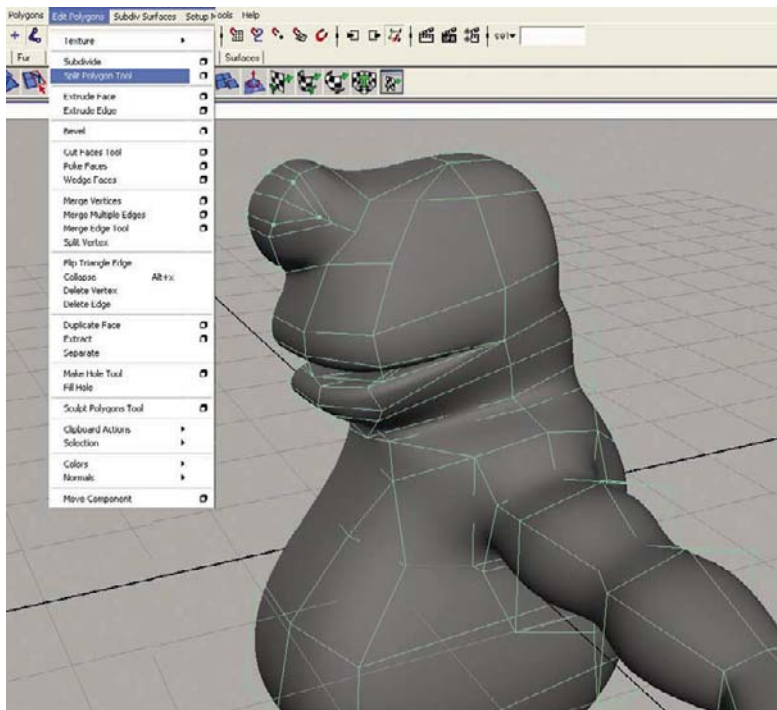
To create the fingers, select the polygon located on the edge of the hand. Split the polygon into five polygons in the area that will become the base of the fingers. Three fingers will be extruded from five polygons.

To finish the detail of the fingertip, go to the top menu and select Edit Polygons > Poke Faces. Move the vertex located in the middle of the polygon at the fingertip to add a nice finishing touch to the fingertips.

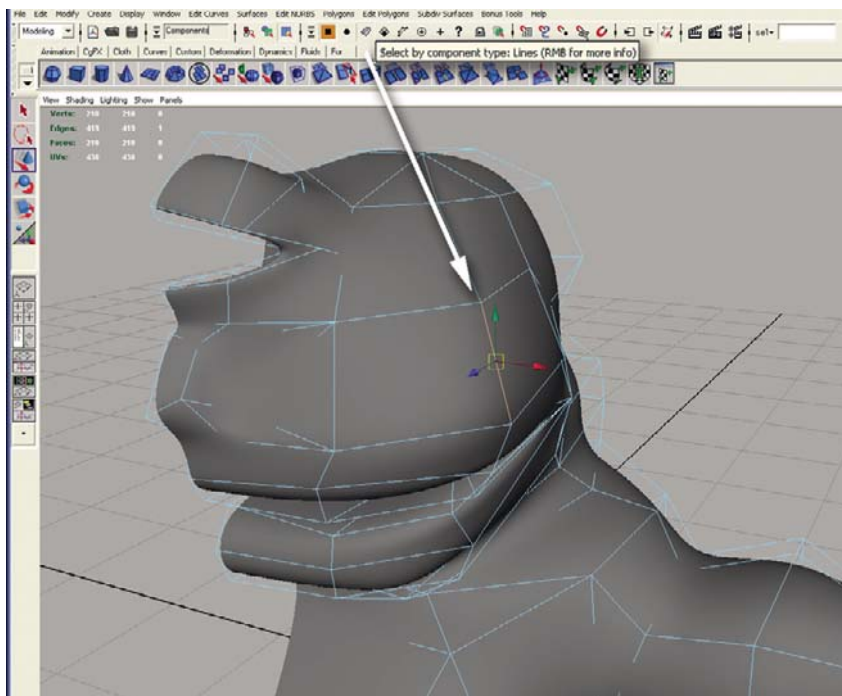
Repeat the same operation to create the thumb. Select the polygon on the side of the hand. Use the Extrude Face tool, move the new polygon, extrude again, and poke the face. Move the vertex located in the middle of the polygon at the fingertip to get a nice finish of the thumb.

The same operations can be repeated for the leg and the toes.

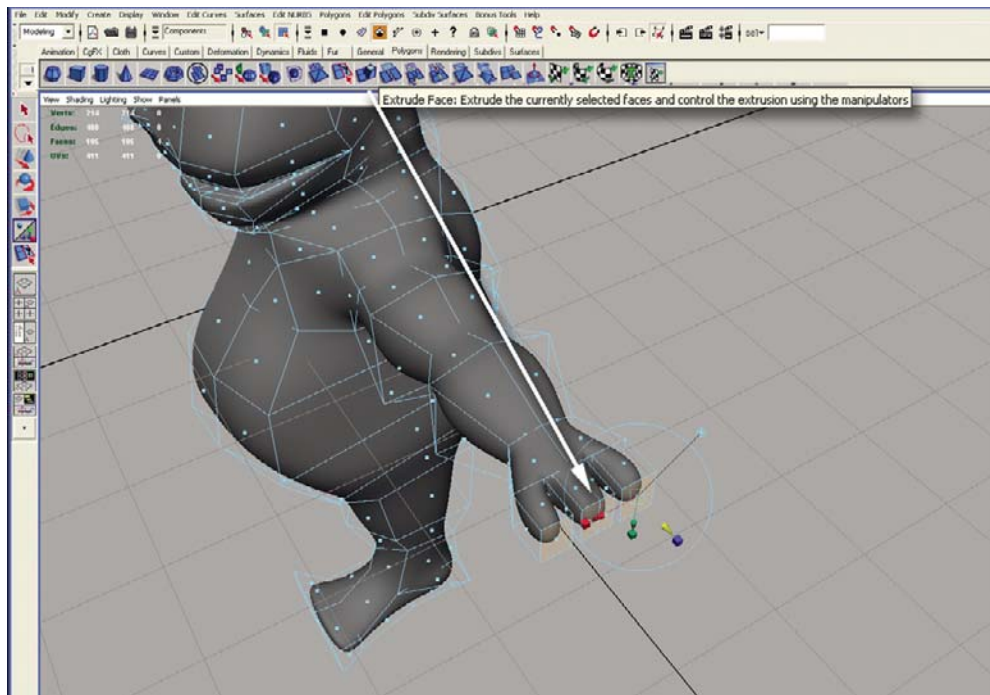
Once you enjoy the look and feel of half of the character's body, you can convert the 3D model to a polygonal mesh.



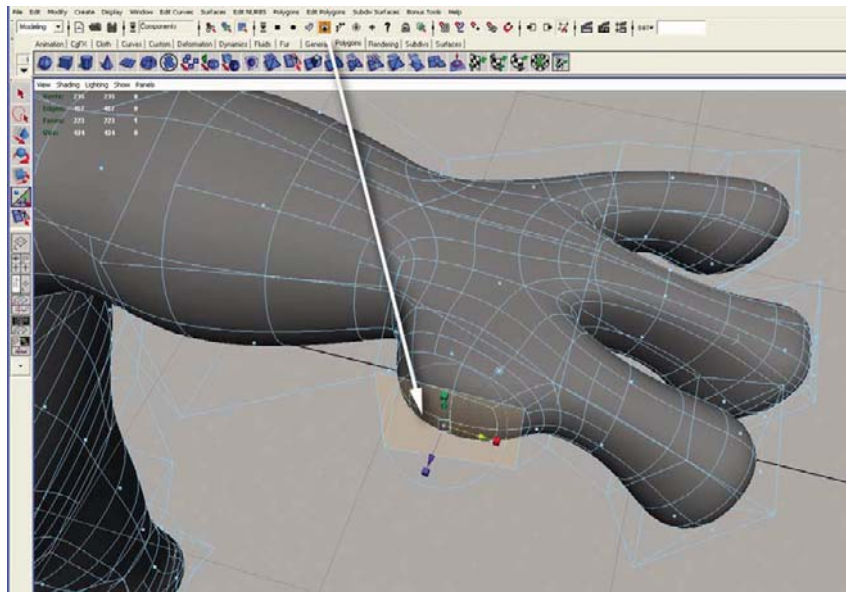
The split polygons tool will let you create small details such as the eyes, the nose, and the fingers.



Selecting the edge of a polygon.



To create the fingers, select the polygon located on the edge of the hand. Split the polygon into five polygons in the area that will become the base of the fingers. Three fingers will be extruded from five polygons. Move the vertex located in the middle of the polygon at the fingertip to add a nice finishing touch to the fingertips.



Use the Extrude Face tool to create the thumb.