# [digital] VISUAL EFFECTS & COMPOSITING

JON GRESS

# [ d i g i t a l ]
# VISUAL EFFECTS & COMPOSITING

New Riders

JON GRESS

# [digital] Visual Effects and Compositing

Jon Gress

New Riders
www.newriders.com

To report errors, please send a note to: errata@peachpit.com

New Riders is an imprint of Peachpit, a division of Pearson Education.



**Acquisitions Editor:** Karyn Johnson
**Project Editor:** Nancy Peterson
**Development Editor:** Corbin Collins
**Copyeditor:** Rebecca Rider
**Proofreader:** Darren Meiss
**Technical Reviewer:** William Vaughan
**Indexer:** Jack Lewis
**Production Coordinator:** Tracey Croom
**Compositor:** Kim Scott, Bumpy Design
**Cover Designer:** Charlene Will
**Interior Designer:** Maureen Forys, Happenstance Type-O-Rama
**Cover Image:** Jon Gress



ISBN 13: 978-0-321-98438-8
ISBN 10: 0-321-98438-2

9 8 7 6 5 4 3 2 1

Printed and bound in the United States of America

*To my three angels…*
*Brittany, Nastasia, and Sofia*
*with all my love.*

# Acknowledgments

I would like to begin by giving special thanks to my good friend William Vaughan. William is, by far, the most talented artist I've ever met. We share a common kinship—a love and passion for teaching the arts we ourselves love. William was kind enough to recommend to Pearson that I write this book, make the introduction, and then even come on board to handle the technical editing. I am always delighted by how insightful he is and by the straightforward, pull-no-punches honesty that we have with one another. I will always look forward to an opportunity to work alongside Will. This book would not have been possible without him.

I would also like to thank Karyn Johnson, Nancy Peterson, and the rest of the wonderful team at Pearson who allowed me the opportunity to create this book for you. Special thanks to Corbin Collins for his amazing attention to detail and for putting up with me whenever I bucked convention. I have, no doubt, become a better writer as a result of his guidance and patience.

No show of thanks would be complete without thanking the many outstanding creative people I've worked with, taught with, bounced ideas off of, or learned a trick or two from over the years, and who have helped inspire and shape what this book is, including Ron Thornton, Glenn Campbell, Bill Holshevnikoff, Scott Billups, Andrew Kramer, John Knoll, Ron Brinkman, Mike Seymour, John Montgomery, Ryan Pribyl and Debby Furnival at FXPHD, Jeff and Ann Scheetz, Saham Ali, Dave West, Mike Young, Craig Nesbit, Jason Pichon, Dan Smith, Michael Keith, Ed Ruiz, Matt Jolly, Anthony Marigliano, Amy Putrynski, Emma Webb, Errol Hanse, Pavel Hristov, Les Foor, Andrey Kasatsky, Justin Wildhorn, Matthew Wuenschel, Dylen Valesquez, Anthony Sollitario, Steve Porter, Beth Lockhard, the Digital Animation & Visual Effects School, Amir Rubin, Anna Vittone, Christian von Kleist and everyone at Paracosm, Enoc Burgos and the crew at Reallusion, every cast and crew member I've had the pleasure of working with over the years, all my students (whom I've always regarded as future colleagues who I just needed to quickly bring up to speed), and Kenny Pederson (for recording a year's worth of my classes, which allowed me to look back, reference, and recall subtle nuances that were important to students over the years).

I would also like to thank my dad and Jinny for all of their love and support and no words could ever express my thanks to my three angels, my daughters, Brittany, Nastasia, and Sofia for being my inspiration, the lights of my life and for being so amazingly understanding of their dad being "not-really-there-even-when-he-was-there" sometimes during the writing of this book. I love you girls more than words can ever say!

And last but not at all least, I dedicate this book to my mom who has always been my biggest supporter and champion. I love you, Mom!

# Contents


Foreword xv
Introduction xvii

**Chapter One Film and Video Primer Boot Camp for VFX 3**

Intro to the Motion Picture/VFX Pipeline 4
- What Are Moviemaking and VFX? 4
- Principles of Motion Pictures and VFX: Film School Crash Course 7

The Origins of Visual Effects 22
- Thomas Edison and Alfred Clark: Stop Motion 22
- Georges Méliès 23
- Oscar G. Rejlander 28

In the Beginning: In-Camera Effects 30
- Single-Pass In-Camera Techniques 30
- Matting for Multiple Exposure 41
- Traditional Animation 42

VFX Cues 43
- Camera 43
- Lights 48
- Depth and Atmospherics: Identifying Depth and Atmospheric Attributes 52
- Media: Identifying Film/Video Stock (Grain/Noise) Attributes 53

Tech and the Digital Realm: The Binary World and Digital Formats 53
- Data Transfer, Color Depth, and Compression 55
- Formats 59
- Resolution and Aspect Ratio Comparisons 59
- The Human Eye vs. Film and Video 62
- Shooting Speeds 62
- Format Comparisons and "What Is Film Look?" 62

VFX Concepts 64
- Thinking in Layers 65
- Complex and Multisource Operators

(Blend/Transfer Modes) 69
Extractions 71

**Chapter Two** **Introduction to VFX: Advanced Photoshop for 3D, VFX, and Digital Compositing** **73**

Photoshop Selection Methods 74
Simple Selections 74
Alpha Channels 77
Advanced Selections 78
Levels Adjustment 79
Channel Ops 80
Application of Selection Methods: Grunge and Grime Maps 84
Procedural Extraction of Grunge and Grime Maps 84
The Five Magical Uses of Grunge and Grime Maps 87
Other Matched Texture/Layer/Element Sets 95
Cloning 98
Basic Cloning Techniques, Tips, Tricks, and Strategies 101
2D Visual Effects 104
Paint: Wire and Wig Removal 104
Matte and Roto 105
Compositing 108
Compositing Applications 109
Layer-based Compositors 110
Nodal-based Compositors 110
Keyer Types and Concepts 111

**Chapter Three** **Rotoscoping, Motion Tracking, and 2D Matchmoving** **115**

Introducing Roto 116
Rotoscoping Mattes 116
Roto Basics: Types of Rotosplines 117
The Golden Rules of Roto 119

Isolated Roto for Keying 122
Roto Applications 122
2D Motion Tracking 123
Anatomy of a Motion Tracker 124
Types of 2D Motion Tracking 124
The Golden Rules of Motion Tracking 126
Comparing Good and Bad Tracking Targets 128
2D Motion Tracking Applications 132
Tracker Assisted Roto 134
2D Matchmoving 136
Stabilization 137
Destabilization 137
Advanced 2D Tracking Strategies 138
Hand 2D Matchmoving 139

**Chapter Four 3D for VFX 143**

How 3D CGI Is Created 143
3D Applications 150
Maya 150
3ds Max 151
LightWave 3D 151
Cinema 4D 152
Modo 152
Blender 153
3D Motion Tracking 153
3D Motion Tracking Application Technique 155
3D Motion Tracking Applications 159
3D Matchmoving 162
Advanced 3D Tracking Strategies 162

**Chapter Five VFX Techniques I: Basic Integration VFX171**

CG/VFX Lighting and Integration 172
Method and Technique for VFX Element Lighting 173
2D Motion Tracking and CG Integration 176
Step 1: Analyze the Shot, Elements, and VFX to Be Created 177

Step 2: Light the Live Action Bluescreen/ Greenscreen or 3D CG Element to Be Integrated 177
Step 3: Track the Live Action Background Plate 179
Step 4: Composite and Matchmove Foreground Element over Live Action Background 179
Step 5: Fine-tune Color Correct (CC) and Finish Composite Adding Grading, Grain, Atmospherics, Artifacts, and More 180
Roto VFX: Energy Weapons and Effects 185
Components of an Energy Weapon or Effect 185
Tips and Tricks for Energy VFX 189
Basic 2.5D VFX 191
Basic 2.5D VFX 191
2.5D Fake Shadows and Reflections 191

**Chapter Six VFX Techniques II: Advanced Integration and Card Trick VFX 197**

Fine-Tuning Integration: Film Grain/Video Noise Matching and Light Wraps 197
Matching Film Grain and Video Noise 197
Creating Procedural Light Wraps 202
2D and 2.5D Crowd Replication 206
2D Face Replacement 210
Card Tricks: Outside-the-Box Strategies 214
The Grid 214
House of Cards 220
For the Birds 222

**Chapter Seven VFX Techniques III: 3D VFX 227**

3D Tracking and Matchmoving CG 228
3D Tracking 228
3D Matchmoving CG 233
Hand 3D Tracking: Matchimation 237
3D Object Tracking and Replacement 246

**Chapter Eight VFX Techniques IV: 2.5D VFX 255**

2.5D Atmosphere FX 255
2.5D Smoke: Cloud FX 260
Faking Z-Depth and Ambient Occlusion 263
Fake Ambient Occlusion (AO) 263
Fake Z-Depth 267
Displacement FX: Water, Heat, Cloak 272

**Chapter Nine VFX Techniques V: Bread and Butter VFX 279**

Sky Replacements 279
Reverse Sky Replacement Method 280
Extraction Sky Replacement Method 283
Day for Night and Summer for Winter 285
Day for Night 285
Summer for Winter 297
Digital 3D HUD Creation 302
Wire and Rig Removal 306
Time Ramping 310
Multi-pass Rendering and Compositing 313

**Chapter Ten Advanced VFX Techniques I: Digital Matte Painting and Environment VFX 323**

2.5D Compositing 323
Digital Matte Painting and Set Extensions: 2D, 3D, and 2.5D 327
Advanced 2.5D Camera Movement 339
Complex 2.5D Digital Matte Paintings and Camera Projections 343
Complex 2.5D Digital Matte Paintings 343
Camera Projections 348
Digital Environment Applications 354
Vue 354
Terragen 354
World Machine 356

Virtual Sets 357
Virtual Studio 358

Chapter Eleven **Advanced VFX Techniques II: Beauty and Restoration VFX** **365**

Film Colorization 366
Digital Beauty 370
Digital Makeup and Tattoos 370
Digital De-Aging 373
Advanced Lighting and Rendering 376
Global Illumination, Radiosity, and Image-Based Lighting 376
High Dynamic Range Images and Light Probes 379
Baked sIBL and Spinning Light Rig Solutions 382
Studio No Lighting Radiosity Lighting 385

Chapter Twelve **Advanced VFX Techniques III: Particle Systems, Dynamics, and Simulation VFX** **389**

Introducing Particle Systems 390
Null Objects 390
The Components of a Particle System 390
Particle System Rendering: Partigons and Non-Rendering Nulls 396
Voxels and Voxel-Based Particle System Rendering 397
Sprite-Based Particle System Rendering 400
Linked 3D Geometry-Based Particle Systems 401
Introducing Dynamics 401
Rigid Body Dynamics 401
Bullet Dynamics 403
Soft Body Dynamics 403
Specialized Fluid Simulation and Dynamics Applications and Plugins 404
RealFlow 404
TurbulenceFD 405
Other Fluid Dynamics Applications 407

## Chapter Thirteen Advanced VFX Techniques IV: Particle, Crowd, and Destruction VFX 409

2.5D vs. 3D Particle-Based Crowd Replications 410
- 2.5D Crowd Replication 411
- 3D Particle-Based Crowd Replication 414

3D Particle-Based Debris Systems 418
Digital Destruction 420
- Putting It All Together (or Blowing It All Apart) 422
- 3D Model Substructures 423
- Hull Burn and Dematerializing VFX 426
- Muzzle Flashes and Fake Interactive Lighting 429
- Bullet Hits 431

## Chapter Fourteen Stereoscopic 3D and 2D to 3D Conversion VFX 435

Guerrilla/Hacker-Style DIY 3D Glasses 436
History, Background, and Core Concepts 436
Creating Stereoscopic 3D 439
- Stereoscopic Cameras and Camera Rigs 439
- Creation of Stereoscopic 3D 439
- 3D Animation 446
- Creating Color Anaglyph Stereoscopic 3D 447
- Creating Black and White Anaglyph Stereoscopic 3D 448
- Channel Shift and 2D Layer Extraction Offset 449
- 2.5D Layer Offset 450
- Photoshop 3D Tools 452
- Pulfrich Effect 453

2D to 3D Stereoscopic Conversions 454
- Methods of 2D-to-3D Stereoscopic Conversions 454
- Technology and Implementation 454

**Chapter Fifteen Advanced VFX Techniques VI: Cutting-Edge 3D VFX 461**

Advanced 3D and Photoshop Magic 462
Vanishing Point Photogrammetry 462
3D Extractions 466
3D Re-Lighting 467
Displacement Modeling 470
Procedural Futuristic or Space Complex Design 470
Creating Complex Terrains Using DEM and SRTM Data 474
xQuick and Dirty Procedural City Extractions Using Displacements 478
New Technologies 482
Ricoh Theta 482
Reallusion iClone, 3DXchange, and Mocap Plugin 484
123D Catch 487
X-cam and Paracosm 488
A Final Note to You 491

**Appendix The VFX Compositor's Checklist and Other Resources 492**

The VFX Compositor's Checklist 492
Key Phrases to Live By as a VFX Artist 494
VFX Artist Quick Reference Lists 494
Starting Your VFX Career 501

Index 506

# Foreword

Since ancient times, magic has been a common source of entertainment. *Magic* is the act of entertaining an audience using tricks to create illusions of the impossible using natural means. An artist who performs magic is often called a magician or an illusionist, which has led me to think of visual effects artists as digital illusionists.

Visual effects artists have taken illusions to previously unimaginable places over the years and have carried on the legacy of the many illusionists who went before them. One attribute that separates a traditional illusionist from his digital counterpart is secrecy. Whereas traditional magicians kept secrets to preserve the mystery of their tricks, the best visual effects artists I know are quick to break down their digital illusions and share them not only with other VFX artists, but the audiences as well.

My career has afforded me the opportunity to work with many of these talented VFX artists over the years, both in productions and in the classroom. To produce digital illusions, VFX artists' primary skill is problem solving. Visual effects instructors must attain high levels of problem-solving ability, but they must also acquire the ability to pass their knowledge onto others. Finding a VFX instructor is easy. Finding a great instructor with the ability to inspire and create production-ready artists with the needed skills often feels like a magic trick of its own.

Jon Gress is among the rare breed of VFX artists who can move seamlessly between problem solving on a production and imparting his experience in the classroom. To truly appreciate Jon as a VFX artist, you have to see him in action during a production. I first met him ten years ago while he was directing the award-winning, live-action, visual effects-heavy student short film *NASA Seals*. I walked into the studio during the last few weeks of production and witnessed what looked to be chaos and a production that was out of control. It turns out, it was orchestrated chaos.

At the time, Jon was filming a few greenscreen pick-up shots of an actor floating off into space, directing artists working on several digital destruction shots, and fine-tuning the edit, among other things. It was fun watching how trivial he made the whole process look and how he effortlessly motivated the team of artists, even at the 11th hour of production, when most teams would be discouraged. It's no real surprise that some of those artists went on to work at studios like Digital Domain, WETA Digital, Zoic, Pixomondo, The Asylum, Cinesite, Prime Focus, and Walt Disney Animation Studios.

A couple years later, I recommended that the Digital Animation and Visual Effects School at Universal Studios hire Jon as the VFX instructor. The school was in the process of retooling its curriculum and needed someone with Jon's experience to come in and help enhance the training the school was providing. Shortly after Jon came on board, the quality of the work being produced by the students increased exponentially. More importantly, the students had a newfound love of the art of visual effects.

Jon brings a contagious energy to anything he is involved with, and he is passionate about the craft of filmmaking. Couple that with his hands-on experience with and knowledge of VFX and his ability to problem-solve and you have the skillset needed to train the next generation of digital artists.

Over the years, Jon has helped to keep movie magic alive and thriving by training hundreds of artists who have gone on to work on everything from summer blockbuster feature films to award-winning television series, and more.

When I heard that Jon was going to be writing a book on visual effects, I was excited that his knowledge would finally be bottled and find its way into the hands of more artists.

Throughout the pages of this book, Jon introduces you to the magic of visual effects and imparts his knowledge so that you can create your own digital illusions. Your audience will walk away knowing that what they saw couldn't have been real—but they will still believe.

—William Vaughan, Academic Director,
Digital Animation and Visual Effects School

# Introduction

Over the past 20 plus years, I've done just about every job imaginable in the worlds of movies, TV, radio, and music—from writing, producing, directing, and visual effects supervising to cinematography, recording, and even performing. I'm one of those fortunate people who has always just known what they wanted to do… make movies.

I made my first "film" at four years old (see Figure 1) by hijacking my father's 8mm film camera and sneaking outside to surreptitiously film the gardener. It was by no means an epic, but even at that young age, I was already fascinated with movies. I had been bitten by the bug that early filmmakers called *silver addiction* (so named because of the filmmaking obsession that required expensive silver halide-based film stocks and processing the love and need to make movies. I knew, even from early childhood, that I wanted to be on the cutting edge of any new technology that could bring any vision imaginable onto the silver screen and into reality.

**[Figure 1]** My first movie (age 4) of the gardener; definitely no epic, but I was hooked!

By the time I was writing, producing, and directing my own productions, I found that I needed to constantly, and quickly, be able to bring the people working with me up to speed using these advanced technologies in order for them to be able to effectively help me work on these quests (and they were truly quests). It wasn't long, after repeating these little training sessions over and over, before I began formalizing this "film/VFX crash course" into a complete, concrete, teachable curriculum that I then refined, again and again, over the next decade or so. Eventually, I was formally teaching hundreds of visual effects (VFX) artists who, as a result of this material, are now successfully working at virtually every major visual effects company around the world. This curriculum had evolved into perhaps the fastest and most complete curriculum for becoming a competent and professional visual effects artist.

So that is what this book is: decades of production experience and more than ten years of refined teaching (training real-world visual effects artists—some with absolutely no experience at all), distilled into one book you can use to go after your dream of creating VFX and the movies *you* want to work on.

## My Promise to You

I despise fluff, especially when it comes to training materials. Anyone who has read a training book, watched a video training tutorial, or sat through a seminar knows what I am talking about. That moment you heard the ninth regurgitation of a simple example or concept… after you've lost count of the never-ending *ummms* and *uhhhs*… the point after you've contemplated methods of escape from a presenter's incessant slurping, nervous coughing, monotone blathering, or pointless passage… that moment you realize, "Why am I sitting here for this?!! This could have been explained in one simple sentence! Hours ago!" Why is [the presenter] still endlessly drudging on about the same thing?!" Well, I agree with you. In fact, that is the entire premise and reason I am writing this book. I'm just like you. I can't tell you how many times I've exclaimed, "Get on with it already!" while reading training materials or watching a training lecture or video.

My promise to you, as one who can empathize, is that I will present to you, in as streamlined and concise a manner as possible, everything I can to make you an excellent VFX artist with *no fluff*.

## What to Expect from This Book

If I do present something that might *seem* like fluff, be assured, it isn't. Any example or information I include related to film, video, art, history, and so on, or something that might seem to be extraneous, has been carefully selected and is included for a very precise and practical purpose. Usually, it is because the example is one of the earliest, and thus easiest to understand, and can form the basis for a very complex concept I cover later in the book.

I have taken a lot of artistic license with some of the scientific and technical information I will reveal and present to you in this book. Years of teaching these concepts and techniques have allowed me to refine them into very distilled forms that are easy to understand, relate to, and remember. I've even distilled some technical information into a "not so perfectly scientifically accurate" form, but one that makes sense to those of us with less-than-alien-sized heads who aspire to be excellent VFX artists, not engineers.

It is my opinion that what is crucial to being a good VFX artist is that you have a solid comprehension of the concepts and techniques of film and visual effects, and that you *do not* necessarily have to know every bit of science behind it or software button to be pushed. I would guess that you probably have no clue as to what the precise spark plug gap measurements are in your car or how to set them, yet you are able to drive perfectly fine. That is why I take a software-agnostic approach wherever possible, unless I am teaching a particular application or making comparisons between applications.

By the time you finish carefully reading this book, you will know most of what you need to know to accomplish virtually any visual effect you can think of. At the very least, you'll know how to proceed to accomplish any effect. Understand, *knowing* is only half of the equation. Actual *doing* must take place as well. With practice and perseverance, I have no doubt you will become the visual effects artist you aspire to be.

## Special Features of This Book

But that's not all. This is not your ordinary book. Oh, not at all. Read on to find out about some of its hidden gems.

## Downloading Files to Use as You Follow Along

I created numerous VFX and other image/movie files to use as examples in this book. I've made many of them available to you for download from the Peachpit website. This way, you can work alongside me, using many of the same files you see in the book's figures.

All you have to do is go to www.peachpit.com/register and follow the instructions for registering this book. After that, a download link will appear, and you can follow that link to retrieve your files.

## Aurasma Augmented Reality–Enabled Features

**[note]**

*Augmented reality* (AR) is a technology that allows the live viewing of a physical, real-world object or environment with elements of it augmented (or enhanced) by computer-generated additions such as 3D graphics, video, images, sound and/or data.

Download the Aurasma augmented-reality (AR) app for your iPhone or Android device, do a search for *visual effects*, and then "follow" the channel that has the picture of the cover of this book.

Open the Aurasma AR viewer, point it at the cover of this book (whether the physical book on your bookshelf or even an image of it that you may come across online), and watch the cover image come to life with a dazzling preview of what's inside the book.

One of the amazing benefits of all of these great new technologies I work with is that I am able to continue to extend the features of this book far past the print version. From time to time, I will post augmented-reality updates to this book to add new tips, tricks, examples, and other amazing new content. I will list these on my website at: http://jongress.com/vfxbook/AR. To use these new updates, just open the book to the page and image listed in the AR Update, open the Aurasma app, and point your device's camera at the image to see the amazing new AR features.

## Stereoscopic 3D Features

Chapter 14 is an entire crash course in stereoscopic 3D creation. To best experience the examples, you will need a common pair of 3D red/cyan glasses. If you don't have a pair of these handy, you can easily find them for around a dollar online by doing a simple web search for *paper 3D glasses*. These cheap paper ones work just fine, but if you plan on doing more extensive stereoscopic 3D work, I recommend that you invest in a pair of more durable plastic ones. If you have trouble finding them, head on over to my website at http://jongress.com/vfxbook/3dglasses and I'll be happy to send you a pair for free (if you just cover the shipping).

But if you're so excited to get started that you just can't wait and you need a pair right now, Chapter 14 includes a make-your-own, guerrilla-style DIY method for creating a pair of 3D glasses in a pinch, using commonly found items; you can use these until your real pair arrives.

### Extended and Bonus Features

Since I am constantly developing new concepts, techniques, and technologies, in addition to the AR and 3D content, from time to time I will also add new tips, tricks, techniques, and info about breaking technologies and more to the book. Check in now and then at the book's website at www.peachpit.com/store/digital-visual-effects-and-compositing-9780321984388 and my website at http://jongress.com/vfxbook.

## How to Use This Book

This book (and accompanying materials) has been refined over my many years of teaching hundreds of Hollywood visual effects artists (Figure 2), to be a complete VFX course and reference. It is designed to take you from your current level of knowledge (whether you are a total VFX novice or have some knowledge already), to a professional level of understanding all the principles, skills, and techniques, from foundations and basics to the cutting edge of working as a professional VFX artist, in the fastest time possible.

**[Figure 2]** Teaching VFX artists live on-set

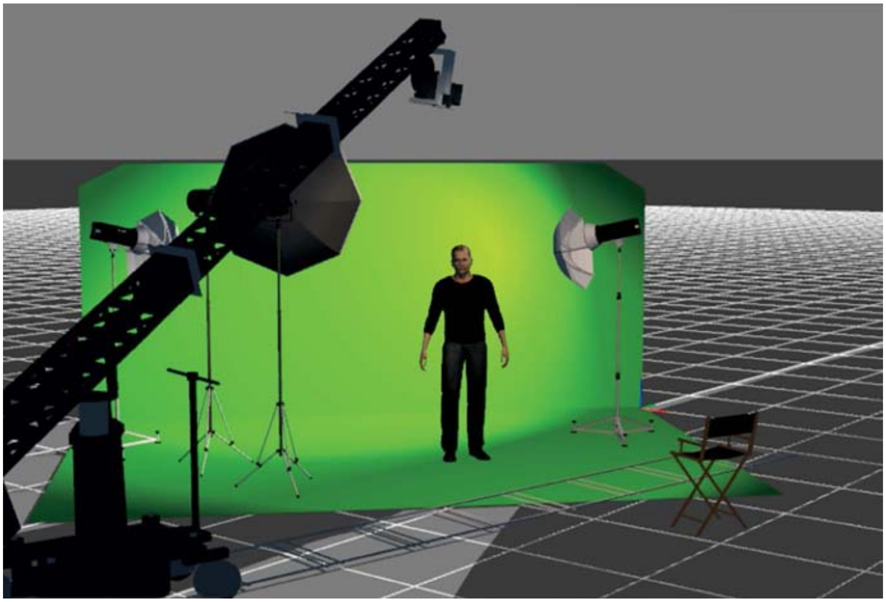
Each chapter builds upon the previous chapter, so your best bet is to read the chapters in order to gain the maximum benefit and then use the book as your go-to reference thereafter.

You may be tempted to skim through Chapter 1, which, in the lecture series I do, is affectionately called "Hell Week" by those I train, owing to the overwhelming and intense amount of technical information that I like to get out of the way as quickly as possible—typically in a week. Nevertheless, I highly recommend reading Chapter 1 in full. It's not critical that you fully comprehend, memorize, or even retain all the information in Chapter 1, but you should try to assimilate as much as you can. By simply being exposed to the information, you will undoubtedly retain much of it by osmosis.

I present much of my material in what I like to refer to as “Miyagi-style” (referring to the character in the movie *Karate Kid*). Mr. Miyagi teaches his student very effective skills, without the student even realizing he’s being taught, through a series of simple, seemingly irrelevant lessons. So many important jewels of knowledge are hidden in the form of analogies, short, true-life production stories, and even simple or seemingly not-so-important skills. Remember my promise… *everything* in this book is relevant. Like Neo in *The Matrix*, you will catch yourself realizing, “Whoa! I know Kung Fu!” (In Chinese, the term *kung fu* (功夫) refers to any skill that is acquired through learning or practice.)

So without further ado… plug yourself in to the matrix… let’s roll!

# [CHAPTER FOUR]



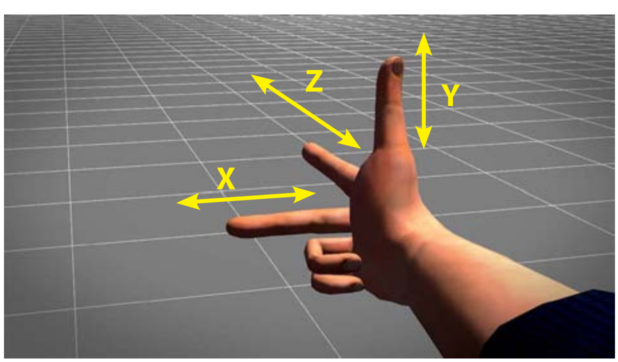
# 3D for VFX

VFX have advanced tremendously since their humble stage beginnings as practical special effects in the late 1800s and early 1900s. With the rapid advancements in computer graphics technologies and techniques in the late 1990s and early 2000s, those models, miniatures, and puppets rapidly gave way to the world of 3D CGI (computer-generated imagery). In 3D, anything can be created—from props and digital prosthetics to entire sets and even full 3D worlds.

## How 3D CGI Is Created

At the heart of 3D CGI is the concept of representing the 3D world on a 2D screen. To do this, computer software must somehow calculate and simulate points in space in the 3D world in order to draw (or render) points (also known as *vertices*) and surfaces (whether polygons, surfaces, normal vectors, also called normals, or faces). We VFX artists use a common mathematical 3-axis system to describe our virtual 3D world.

We call this the XYZ coordinate system. Typically X represents the horizontal axis, Y represents the vertical axis, and Z represents the in and out or depth axis. If you are unfamiliar with the XYZ coordinate system, an easy way to remember it is to hold your fingers like a child pretending to shoot a gun, but with your middle finger sticking out at a 90 degree angle (perpendicular) to your pointer finger, as seen in Figure 4.1. With your fingers in this configuration, as silly as it might look to those around you, your middle finger is the X axis, your thumb is the Y axis, and your pointer is the Z axis.




**[Figure 4.1]** Fingers representing the XYZ coordinate system: middle finger (X), thumb (Y), and pointer (Z)

[note]

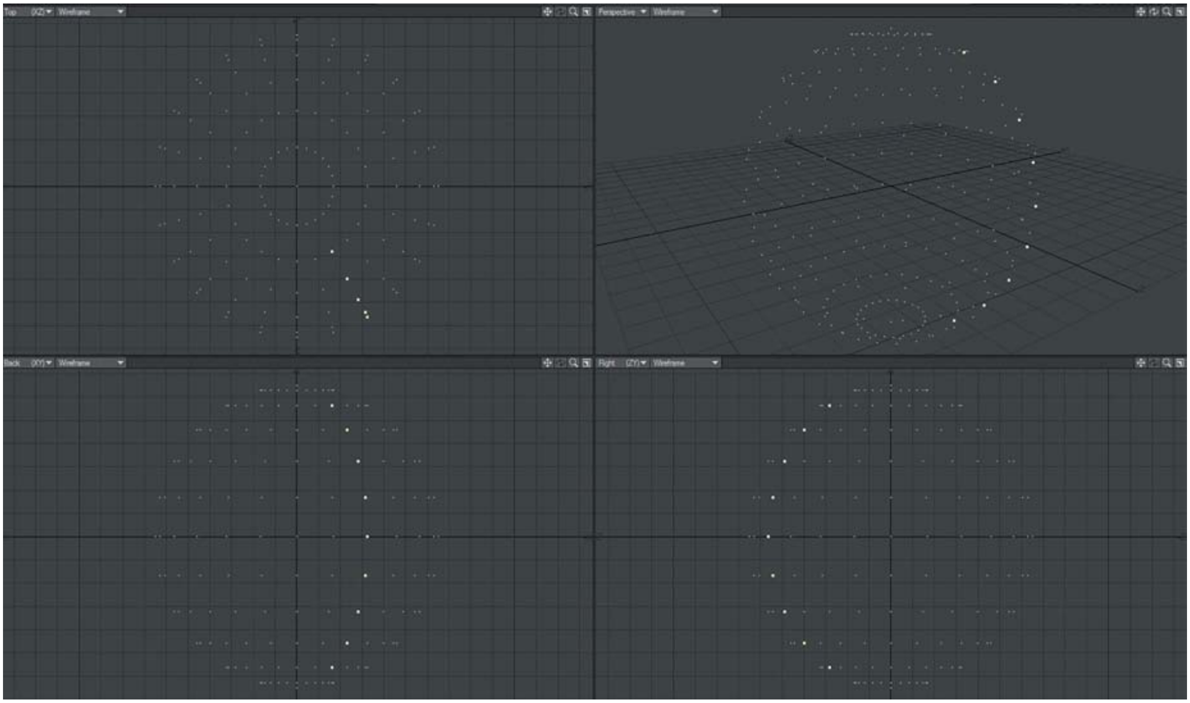
Different 3D applications sometimes assign these axes differently (i.e., Z is assigned to vertical instead of Y), but aside from the naming convention, the concept is exactly the same.

There are a few different methods of creating 3D models, or *meshes*, but they all work pretty much the same way.

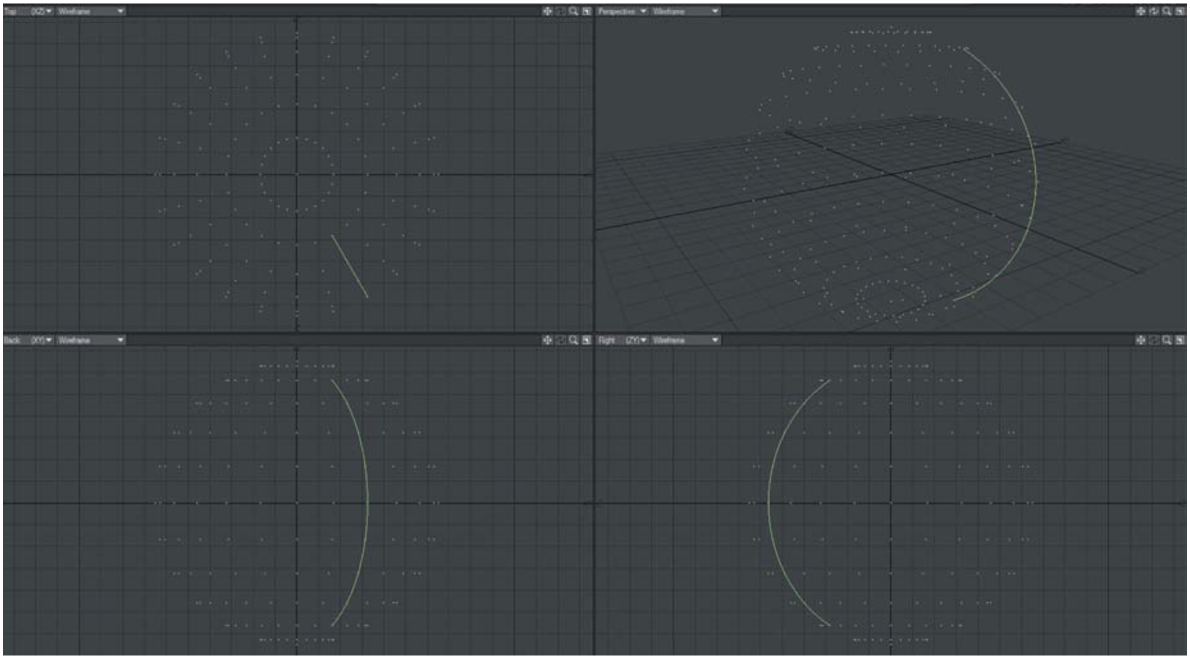
Points (vertices) or curves (also known as *splines*) are created or placed in the virtual 3D environment (see Figure 4.2).These points or curves are then connected to create edges (Figure 4.3). Edges and splines are then closed to create polygonal faces (sometimes referred to as patches), as shown in Figure 4.4.

Primitive 3D shapes can also be created, modified, and combined to more quickly create complex objects, as shown in Figure 4.5.

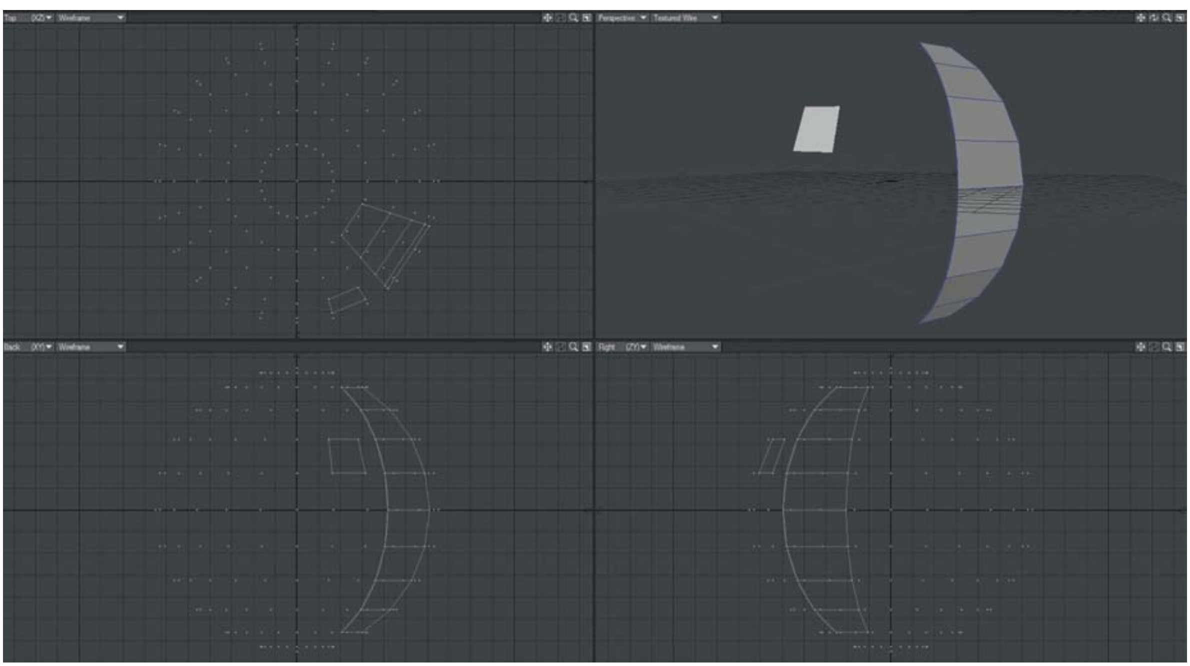
For creating hard surface models such as buildings, furniture, computers, and so on, this method of building 3D models works very well. In cases where more curved or fluid shapes are required (called *organic modeling*), rough or blocky polygonal models' faces, as shown in Figure 4.6, can be smoothed (or subdivided) to create even more complex shapes and models. This method of creating rough blocky polygonal models and then subdividing them into smooth organic shapes is referred to as *subdivision surface modeling*.



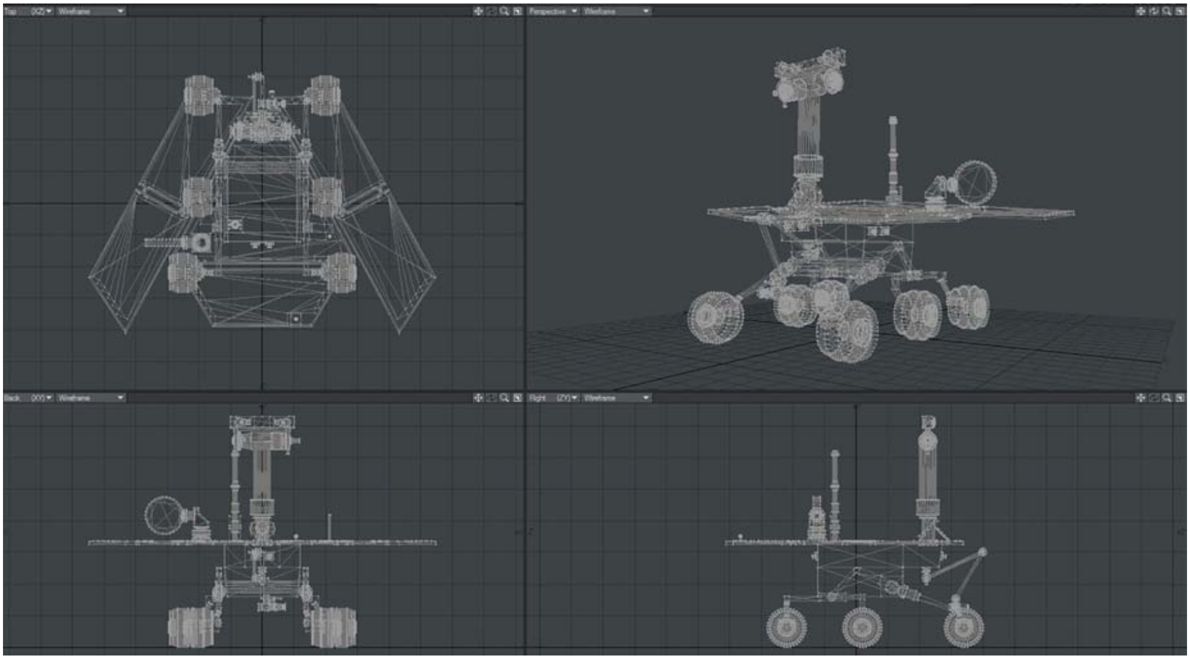
**[Figure 4.2]** Points (vertices) and curves (splines)



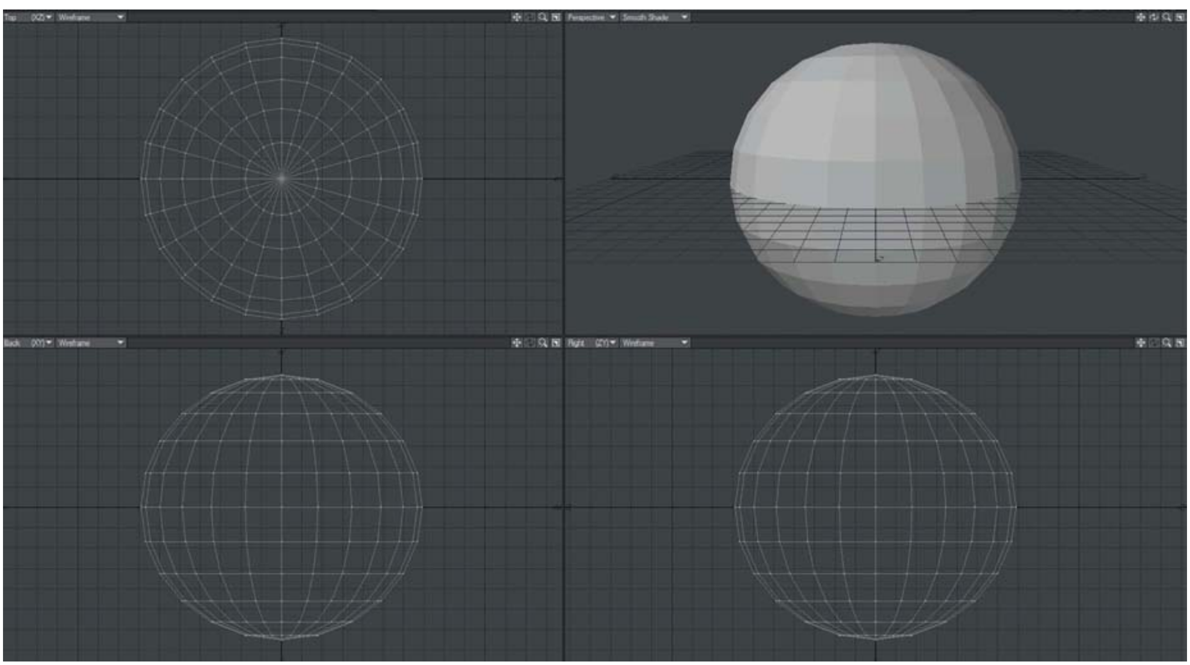
[Figure 4.3] Vertices and splines connected with edges



[Figure 4.4] Edges and splines closed to create polygonal faces



**[Figure 4.5]** Primitives combined to create complex meshes



**[Figure 4.6]** A simple untextured/unsurfaced 3D polygonal sphere

Once faces, or polygons, are created, they can be textured (or *surfaced*) to create the appearance of real or fictional objects. These textures (or *maps*) can be any combination of colors, images, or mathematical procedural operations, as discussed in Chapter 2 in the section "Other Matched Texture/Layer/Element Sets." Textures can then be layered and combined to form complex materials (or *shaders*).

Texturing (or surfacing) is both an art and a science. The most important skill required for great texturing or surfacing is refining your observational skills. Let's take a look at a couple examples.

**[note]**

Although every 3D application has a slightly different approach to texturing/surfacing, the core concepts are identical and ubiquitous among all 3D applications.

In Figure 4.6 you can see a simple 3D sphere.

By carefully observing the details and attributes of the surfaces of other spherical-based objects, you can easily modify the textures and surface attributes of this simple sphere, changing it into many completely different objects.

First, for a simple one, let's create the texture of a billiard ball. Billiard balls are colored and have a high-gloss finish. By setting the value in the color channel—in this case, to blue—and the diffuse channel to 90% (which will give the ball 90% of its reflected color from the blue base color in the color channel), the ball will take on a nice, bright, saturated blue finish (as seen in Figure 4.7).

Because a billiard ball is also very shiny from the highly polished finish, you want to turn the specular value up very high as well (in Figure 4.8, the specular channel is set to 100%).

Notice that the *specular highlight*, or *hotspot* (the white spot reflection of the light source), is very broad and spread out. The tight molecular structure of a billiard ball's high-polish finish creates a very tight highlight spot. To simulate this, you can also increase the glossiness channel to 100%, as shown in Figure 4.9.

**[Figure 4.7]** 3D sphere with Blue selected in the color channel and the diffuse channel set to 90%

**[Figure 4.8]** Specular channel set to 100%


**[Figure 4.9]** Glossiness set to 100%

**[Figure 4.10]** Mirrored gazing ball reference image

**[Figure 4.11]** A 180-degree spherical image of a park loaded into the environment reflection channel

**[Figure 4.12]** The finished 3D CGI mirrored gazing ball

That gloss finish means that it is partially reflective. So you can also add a slight amount of reflectivity to the reflection channel, which gives a nice re-creation of a billiard ball's texture. Of course, for a production, as discussed in Chapter 2, you would want to add the number decal and many imperfections to the surfaces, such as dings and dents in the finish and even chalk marks and fingerprints to dull down the finish in some areas for added realism.

Next, let's look at the mirrored gazing ball reference image in Figure 4.10.

From the very first glance you can see that the gazing ball really has no color of its own, but instead, because it is so highly reflective, it gets it color from the reflection of whatever is around it—in this case an outside park scene. By turning the diffuse map to black (or zero), you turn off any base color the sphere would have. You can also set the color map to black since there isn't any. It too is shiny and glossy, so those aspects should be set high, similar to the way they were set for the billiard ball. Finally, you will want to set the reflection channel to 100% (or close to it) since a mirrored ball is definitely reflective. But something's wrong! So far your sphere is just a shiny, glossy black. Actually, the only thing that's wrong is that there's nothing for your mirrored ball to reflect. When you load the image of the exterior park scene (Figure 4.11) where the reference image was taken into the environment or reflection channel, the 3D mirrored ball instantly springs to life, as you can see in Figure 4.12.

Now the ball has become a very accurate re-creation of the original. As with the first example, for a production quality model you would want to add all of the similar "reality imperfections."

Finally, for a completely different spin, let's create a pumpkin. We'll push in the top and bottom of the sphere and reset all of the map parameters; then, using the same technique and dirty warehouse floor texture we used in Chapter 2, we'll create a dirty, desaturated orange texture (Figure 4.13).

Next, since a pumpkin reflects a lot of its own orange color, set the diffuse channel high, to about 80% (to taste of course), the specular channel to about 20% (to give a wide highlight), and the glossiness to between 30 and 40% to emulate the shiny waxy-like surface of a pumpkin. This will give you something that looks like Figure 4.14.

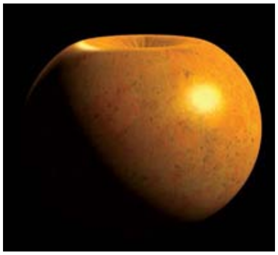
It's always important to *think* about a texture or material thoroughly, the same way you thoroughly need to think through every VFX you create, as described in Chapter 1. If a pumpkin were to have the dirty discolorations that the dirty warehouse floor texture has, it most definitely wouldn't be as shiny on those spots as on the waxy orange surface of the pumpkin skin itself. To simulate this, you can load a matching copy of one of the dirt/grunge textures used to create the orange skin texture into the specular channel to "knock down" the amount of specularity in those spots, as shown in Figure 4.15. This is called *specularity breakup*.

You can now see that those dirty spots are less shiny than the cleaner skin areas. But this still looks more like a partially deflated dirty orange beach ball than a pumpkin. The magic happens in another channel. This channel isn't actually a "texture" channel per se in the material/surface sense, but instead, it is a texture channel used by the modeling engine to *displace*, or push, points/vertices around based on the values of a map (yes, the same kind of map we've been using for textures. This one we just need to think through to use for 3D displacement instead of 2D displacement). As with a bump map, a displacement map pushes the vertices in the 3D geometry down, or in, wherever the map is darker and up, or out, wherever it's lighter. Because

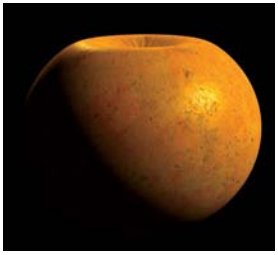
**[note]**

There is no exact science to texturing/surfacing. All of the surface settings described here are starting points and recommendations. Material and texture will always be dependent on the particular model, scene, and requirement and will need to be fine-tuned to taste.

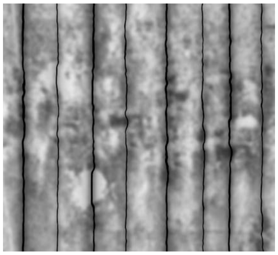
**[Figure 4.13]** A dirty desaturated orange texture



**[Figure 4.14]** The diffuse, specular, and glossiness settings are set.



**[Figure 4.15]** Specularity breakup added to the specularity (spec) channel a pumpkin has organic linear stripe-like vertical indentations, a map with wavy dark vertical lines that gradually fade to white and then gradually back into another wavy black line will push the geometry of the sphere in or out at those vertices on the geometry, respectively, based on how dark or light the map is at any given point. Once this map (Figure 4.16) is loaded into the displacement channel, the deflated sphere magically transforms into a natural looking pumpkin! (Figure 4.17)



**[Figure 4.16]** Displacement map created to simulate the vertical ridges on a pumpkin

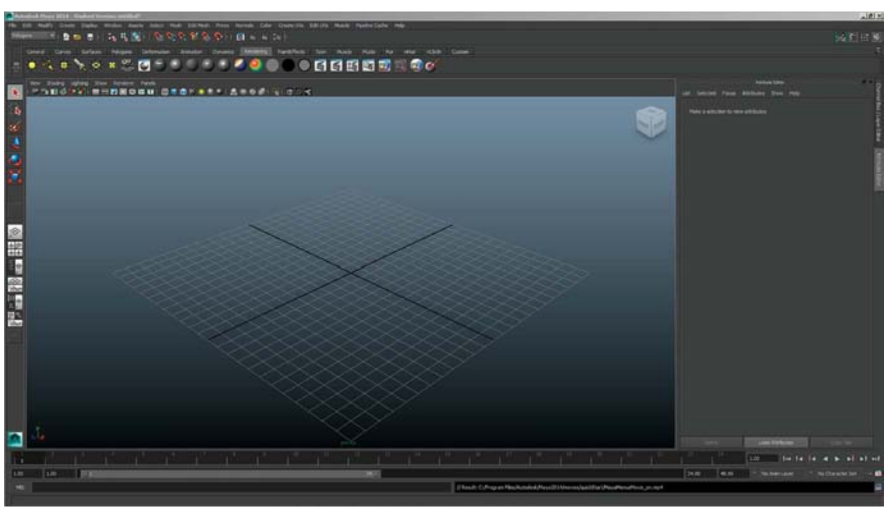
# 3D Applications

**[Figure 4.17]** The finished, displaced geometry pumpkin

There are many 3D applications, and each has its own strengths, style, workflow, and conventions—but the principles for modeling, texturing, lighting, animating, and rendering are all the same. This section introduces the most widely used 3D applications in the industry.

## Maya

Originally spawned from Alias | Wavefront's Power Animator, Autodesk's Maya (www.autodesk.com), shown in Figure 4.18, is one of the most popular, high-end 3D applications in the VFX industry. Maya has a steep learning curve, but has powerful animating and simulation tools and is almost infinitely extensible with its plugin and customization capabilities.



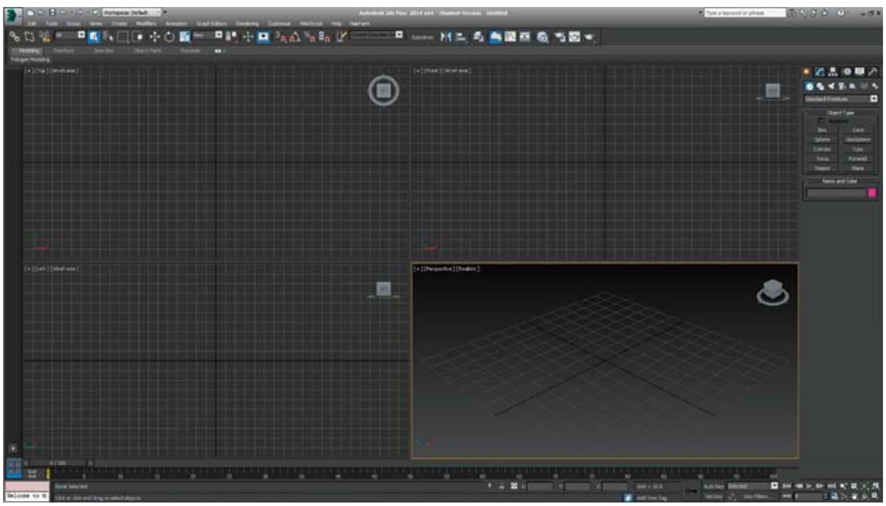
**[Figure 4.18]** Autodesk's Maya user interface

## 3ds Max

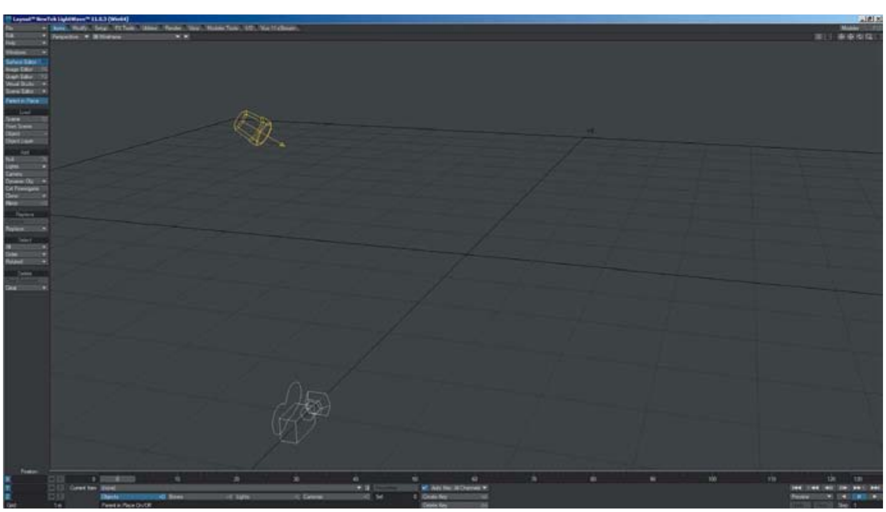
Autodesk's 3ds Max (www.autodesk.com) (Figure 4.19) is also part of the Autodesk family of products. 3ds Max has very strong roots in both architectural and gaming 3D but is widely used in many facets of VFX.

## LightWave 3D

NewTek's LightWave 3D (http://newtek.com) (Figure 4.20) spawned from NewTek's Video Toaster in the early 1990s and, because of its speed, flexibility, and superb renderer, it quickly gained a foothold in television and film VFX, especially in many popular sci-fi series such as *Star Trek* and *Babylon 5*.



**[Figure 4.19]**
Autodesk's 3ds Max user interface



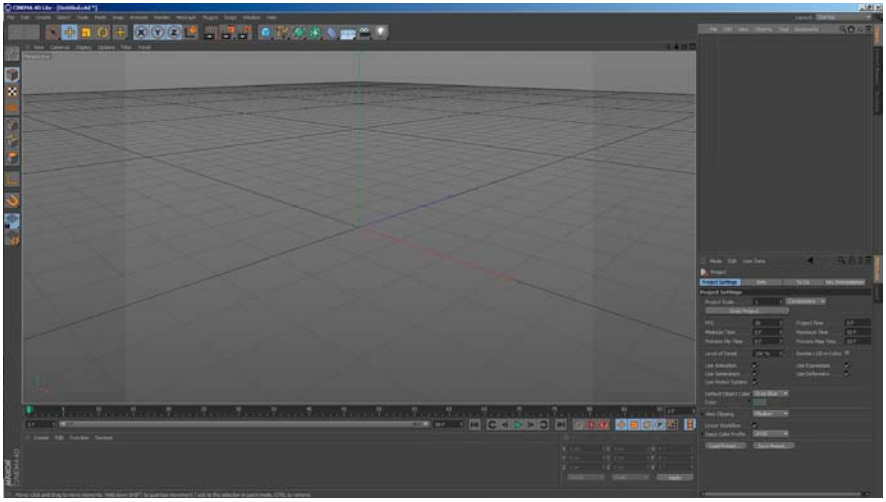
**[Figure 4.20]**
NewTek's LightWave 3D user interface

## Cinema 4D

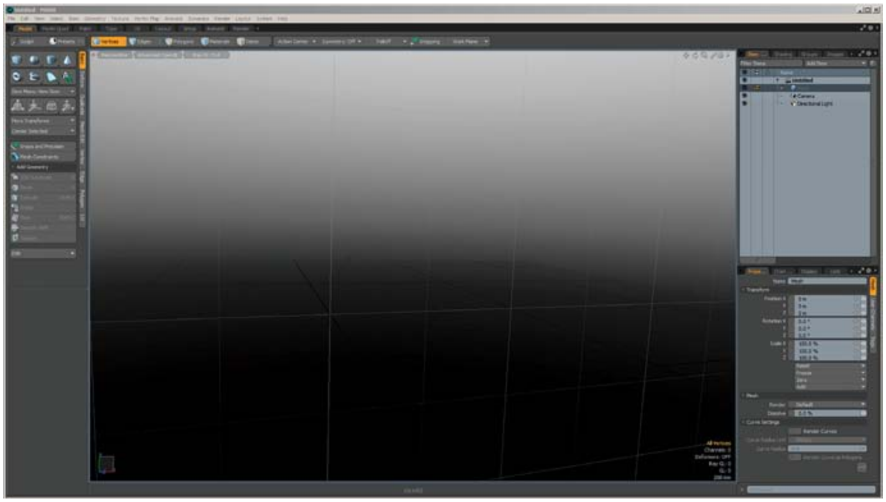
German-based Maxon also released Cinema 4D (www.maxon.net) in the early 1990s (see Figure 4.21). Cinema 4D, though not too popular in those formative years, has quickly grown into a powerhouse 3D application fully capable of stunning 3D and VFX work.

## Modo

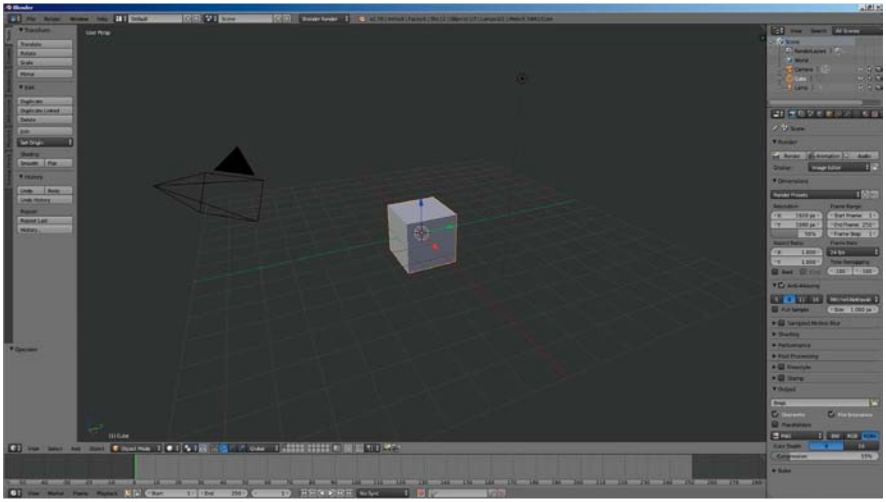
In the early 2000s, some senior management and developers from NewTek, wanting to take 3D software in a different direction, formed Luxology. Their 3D application, Modo (www.thefoundry.co.uk), shown in Figure 4.22, quickly became a leader and favorite in the industry for its innovative workflow and features.



**[Figure 4.21]** Maxon's Cinema 4D Lite user interface



**[Figure 4.22]** Luxology's Modo user interface



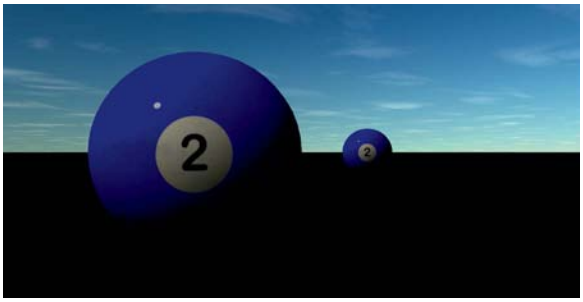
**[Figure 4.23]** Open source Blender user interface

## Blender

Originally created by Dutch animation studio NeoGeo and Not a Number (NaN) Technologies as an in-house 3D application in 2002, Blender (www.blender.org) (Figure 4.23) was released as a free and open source 3D computer graphics software product under the GNU General Public License. Blender has been used in many areas of VFX production and continues to develop amazing innovative features—and all for free!

# 3D Motion Tracking

In Chapter 3, in the discussion of 2D motion tracking, you saw how to track one, two, and even four points on an image to record and utilize the positional/translational, rotational, and *apparent* scaling data. I say *apparent* because what we are actually tracking is the points moving closer together, as shown in Figure 4.24, simulating scale, which will sometimes suffice for creating simulated Z-depth movement.



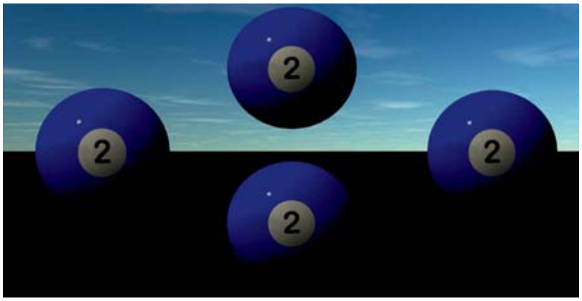
**[Figure 4.24]** Simulated scaling as an object moves closer to or farther away in depth (Z-space) from the camera

Many times this will be sufficient enough data to allow you to lock your element to the plate so you can create a seamless integration. But what happens if the camera is orbiting around or within a scene, or is moving through a scene at an angle, allowing you to see *around* objects in the scene as you pass them? New VFX artists frequently want to know the dividing line between when a 2D track is enough to make a shot work and when a 3D track is required. Well, this is it. Any time the camera *orbits* around or within a scene or translates/passes objects within a scene in Z-depth close enough to reveal the 3D nature of a subject or object (or reveal a portion, or portions, of those objects that weren't seen originally)—as the examples in Figures 4.25–4.28 illustrate—a 3D track and solution is required.

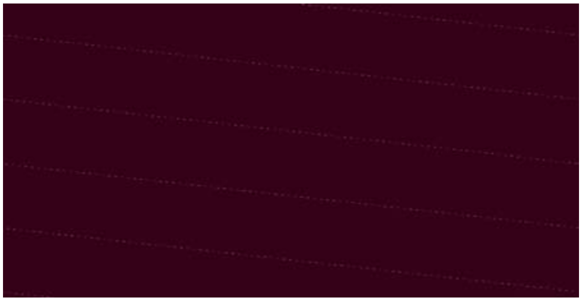
Unlike 2D tracking, which derives its data from the X and Y motion of pixels on a flat screen, 3D tracking utilizes much more complex triangulation calculations to determine objects' actual position and motion in 3D space. If you want to be able to integrate a 3D object into a scene where the camera is moving in three dimensions, you need to be able to re-create this camera's motion in 3D and have your virtual camera repeating this same motion in order for your element to integrate seamlessly.

To be really good at 3D tracking (and to avoid the needless frustration many artists encounter), it's important to understand how 3D tracking works.

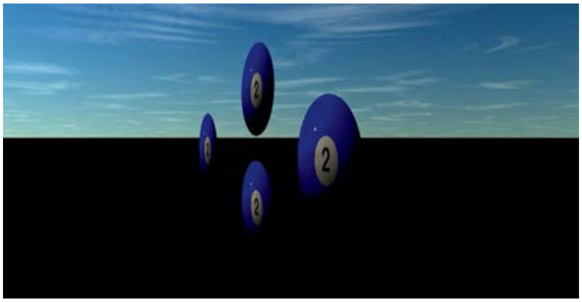
The origins of 3D tracking technologies lie in the science of *photogrammetry*, the scientific method of calculating positions and distances of points referenced



**[Figure 4.25]** XY translation-only camera movement that would work well with a 2D track

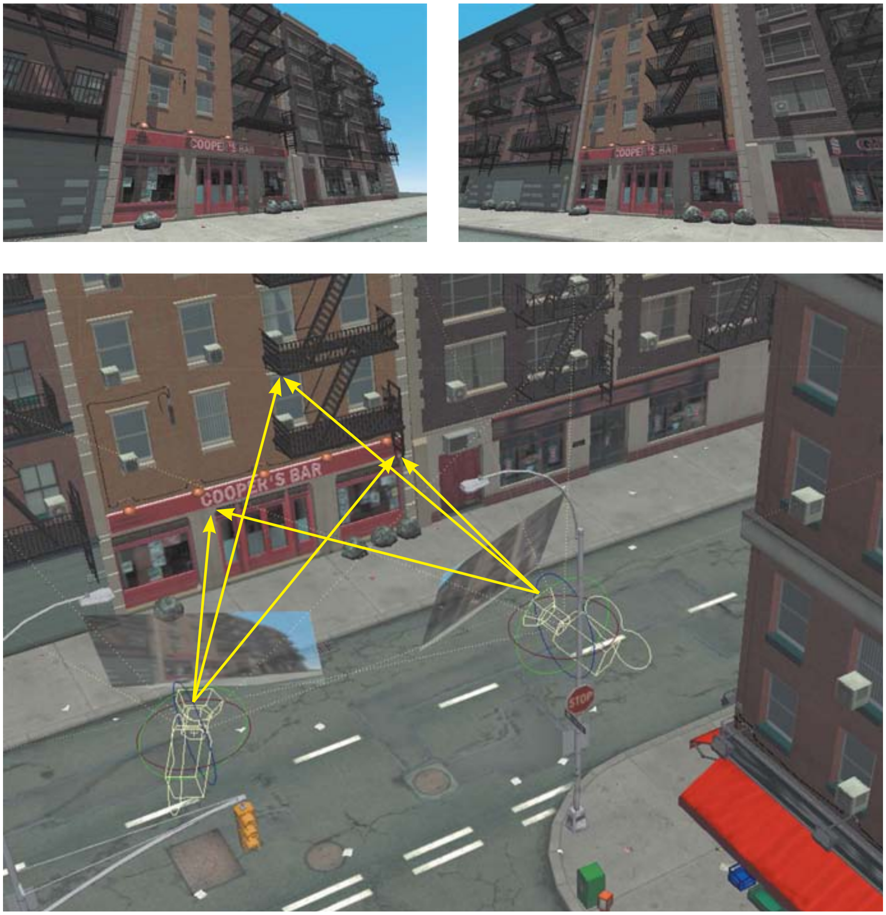


**[Figure 4.26]** Z Translation-only camera movement that would work well with a 2D track



**[Figure 4.27]** Orbital camera movement requiring a 3D track

**[Figure 4.28]** Camera translation close to subject and on an angle so that the 3D nature of the object or subject is revealed.




**[Figure 4.29]**
Points in two images being triangulated to determine camera position

in one or more images. By comparing and triangulating the position of points referenced in multiple images (as seen in Figure 4.29), or consecutive frames of a motion image, the position of those points, as well as that of the camera, can be calculated using trigonometry and geometric projections.

> **[note]**
>
> When doing the auto track, it is important that you mask out any objects in the scene that are creating extraneous motion using the masking tools in the 3D tracking application. These tools create an alpha channel that tells the tracker what areas of the image to ignore and exclude from tracking and calculations.

## 3D Motion Tracking Application Technique

A 3D tracker does its mathematical magic in a series of well-defined steps:

1. A mass (usually automated) 2D track, or *auto track*, of the scene is performed, tracking many (sometimes hundreds or thousands) high-contrast *candidate* (or potential) points in the scene. This first track is almost identical to a 2D track except that it is done on a mass scale on the entire image, as shown in Figure 4.30. During this process, complex software algorithms sift through all of the tracked 2D points to weed out and

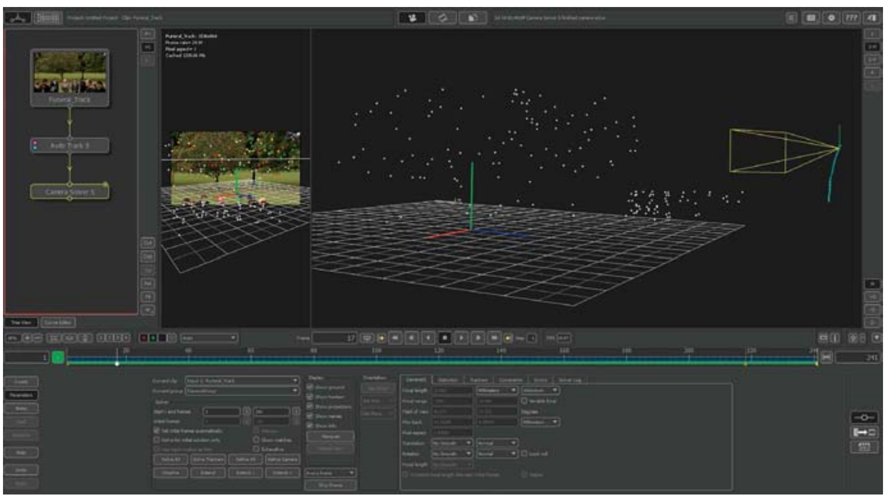
delete any of those that fall below a user set *confidence threshold* (meaning how confident the software is that the point being tracked is the same on each frame or range of frames).

**[Figure 4.30]** The first step in a 3D track is a mass, automated 2D track.

2. Next, a complex 3D *camera solve* is done. A solve is an exhaustive series of calculations wherein the motion of every point tracked is compared and triangulated on a frame-by-frame basis (usually both forward and backward) to determine its position as well as the camera's position and any movement within each frame, as shown in Figure 4.31. The more information known about the camera used and its motion and environment, the more accurate the solve will be.

**[Figure 4.31]** 3D camera solve

3. Once the 3D tracking application completes its solve, it will display the resulting 3D camera, motion track, and *point cloud* (cluster of points representing solved candidate points). The camera's position and track, at this point, are relative to the point cloud and not necessarily aligned with the real world X, Y, and Z axes (as shown in Figure 4.32), so the next step is to *align*, or *orient*, the scene. Most 3D tracking applications have scene orientation tools that allow you to designate a point in the scene as the X, Y, Z, 0, 0, 0 origin. Additional scene orientation can be refined by using tools that allow you to designate certain points as being on a common plane, or that allow you to manually translate, rotate, and scale the entire scene into position by eye, or by aligning to reference grids, as shown in Figure 4.33.



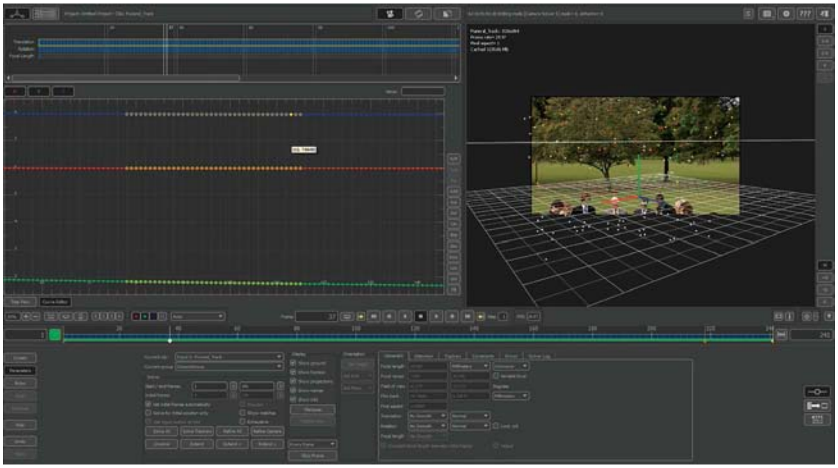
**[Figure 4.32]** 3D camera, track and point cloud

**[Figure 4.33]** 3D orientation and alignment of camera track and point cloud scene

4. At this point, most 3D tracking applications will allow you to place test objects into the scene to determine how well they follow the track (or *stick*), as shown in Figure 4.34.

**[Figure 4.34]**
3D test objects inserted into the 3D tracked scene

5. If there are any errors or errant motions in the track, you can apply mathematical filters to smooth the tracks motion. Averaging, or Butterworth, filters are common filters to accomplish this. Isolated errors or motions may also be edited or removed manually by editing, adjusting, or deleting track motion keyframes, as shown in Figure 4.35.



**[Figure 4.35]**
Editing 3D camera motion track keyframes

6. Once the 3D camera track proves to be solid, the data can then be exported in a variety of file and scene formats to other 3D and/or compositing applications for use.

## 3D Motion Tracking Applications

There are many 3D motion tracking applications, some which come as integrated solutions in other applications, as well as the standalone application variety. Although their workflows and methodologies vary somewhat, they all contain the steps outlined in the preceding section (whether obviously or under-the-hood in the case of completely automated versions). This section introduces some of the most popular 3D tracking applications.

### PFTrack

Originating from the University of Manchester's Project Icarus, PFTrack (www.thepixelfarm.co.uk) (see Figure 4.36) and its sibling applications have grown into some of the most powerful and widely used 3D tracking applications in the VFX industry.

**[Figure 4.36]**
PFTrack user interface

### Boujou

Vicon's Boujou (www.boujou.com) was one of the first almost fully automated 3D tracking applications and still offers a great set of powerful 3D tracking tools, as shown in Figure 4.37.

### Nuke and After Effects

3D tracking has become a commonly integrated feature in compositing applications, which continue to grow and blur the lines between VFX job descriptions. Recently, compositing applications such as The Foundry's Nuke (www.thefoundry.co.uk) (Figure 4.38) and Adobe's After Effects (www.adobe.com) (Figure 4.39) have also integrated 3D tracking capabilities.

**[Figure 4.37]**
Boujou user interface

**[Figure 4.38]**
The Foundry's Nuke 3D tracking interface

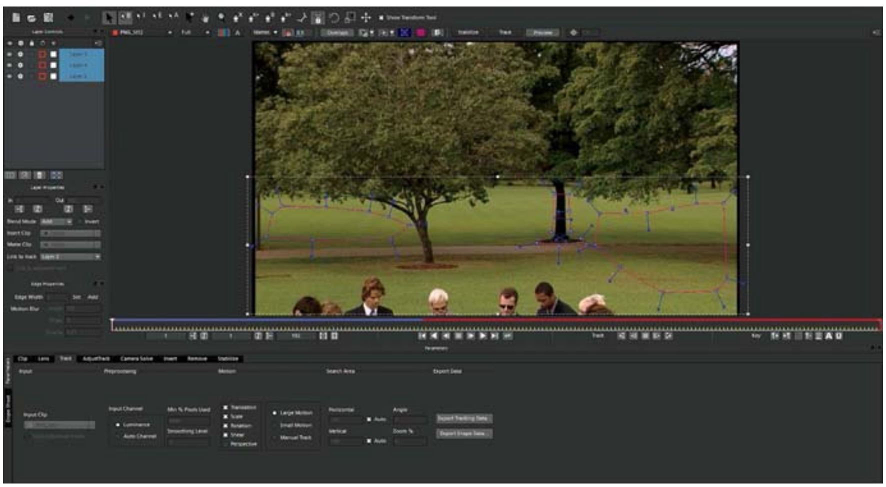
**[Figure 4.39]**
Adobe After Effects' 3D tracking interface

## Mocha

Even Imagineer Systems' planar tracker Mocha Pro (www.imagineersystems.com) (as seen in Figure 4.40) has been given a turbo boost with its ability to extrapolate 3D camera tracking motion from multiple 2D planar tracks, resulting in some very impressive output where some standard 3D trackers fail.

## SynthEyes

One of the first affordable, low-cost, 3D tracking applications, SynthEyes (www.ssontech.com), shown in Figure 4.41, has also grown in capability and features to become a powerful and widely used 3D tracking solution.



**[Figure 4.40]** Imagineer Systems' Mocha Pro user interface


**[Figure 4.41]** SynthEyes user interface

**[Figure 4.42]** University of Hannover's Laboratory for Information Technology's Voodoo user interface

### Voodoo

The University of Hannover's Laboratory for Information Technology developed this free non-commercial 3D camera tracking software. Voodoo (www.viscoda.com) (Figure 4.42) is an excellent tool for beginners to use to experiment with 3D camera tracking at no cost.

# 3D Matchmoving

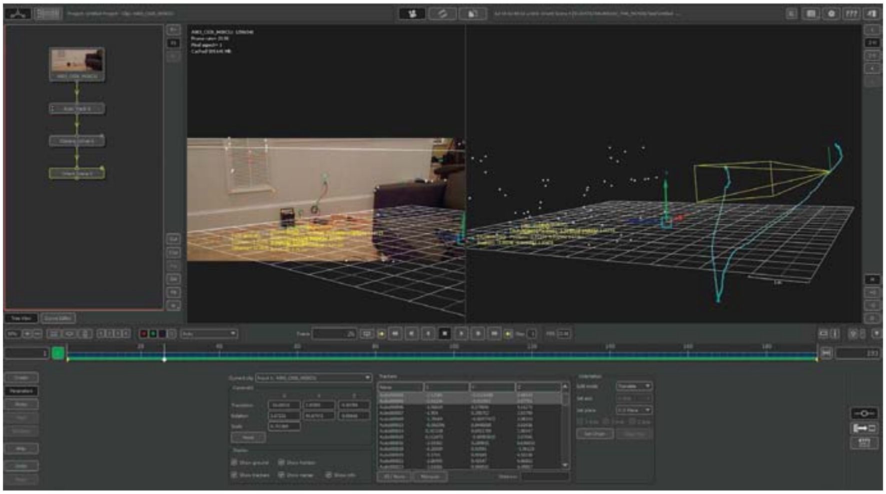
Once a solid 3D tracking solution is exported from a 3D tracking application, creating a 3D matchmove involves little more than setting up a scene and importing the solution into your 3D or compositing application of choice, as shown in Figure 4.43 and Figure 4.44. (See Chapter 3 for much more on matchmoving.)

## Advanced 3D Tracking Strategies

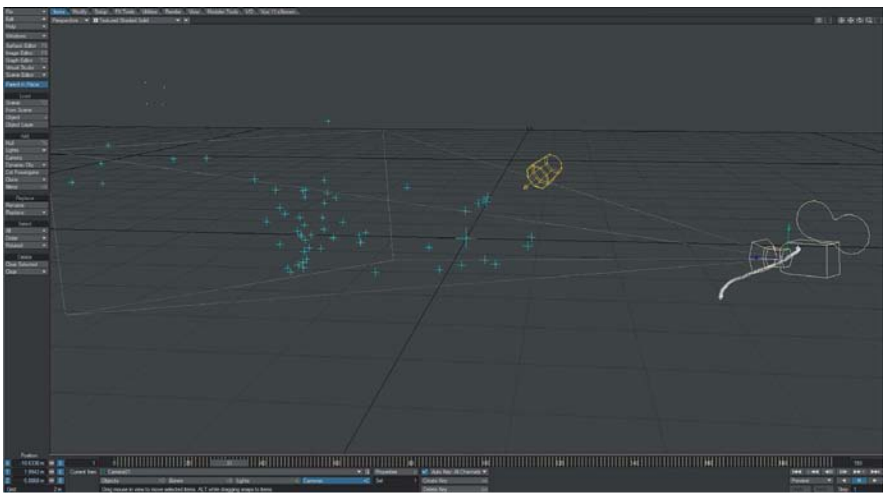
There are many times when it is extremely helpful to know some advanced 3D tracking strategies as well.

### Hand 3D Tracking and Matchimation

Unfortunately, as is usually the case in VFX, 3D tracking is often not quite as simple as autotrack, autosolve, autoorient, and export. Tracks contain too much noise or too many errors or they just downright fail altogether. In these cases, as with 2D tracking and matchmoving, you need a fallback strategy.



**[Figure 4.43]**
3D tracking solution and point cloud in PFTrack



**[Figure 4.44]**
The same 3D tracking and point-cloud solution imported into a 3D application (which depicts tracking points from the point cloud as null objects in the 3D application)

Very similar to the hand-tracked 2D track in Chapter 3, when all else fails, you can hand track, or *matchimate*, a 3D track as well. *Matchimation* is derived from the combination of *matchmove* and *animation* and refers to the process of manual frame-by-frame or keyframe matching a track.

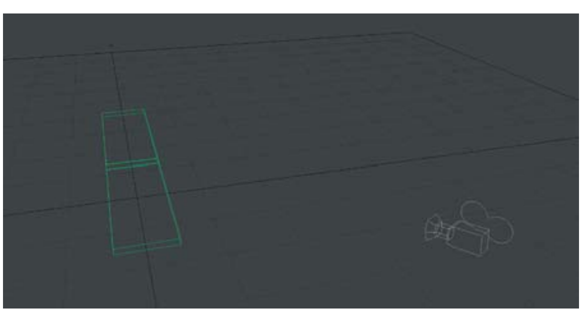
To hand track a 3D scene, you first want to create 3D reference stand-in objects for any scene elements with known sizes and/or positions. You are basically trying to replicate key elements of the scene in your 3D application. Elements nearest to the 3D CG object you intend to place into the scene are the most important to place, if possible. In Figure 4.45 you can see a dolly shot sequence filmed on a bluescreen set, which will become an air traffic control radar monitoring station in this example.

**[Figure 4.45]** Bluescreen VFX sequence to be hand 3D tracked

Load the footage into the background of your 3D application, making sure the footage size and aspect ratio is set correctly in both the background and the scenes camera. Set your 3D models to wireframe view mode so that you can easily see through them to the footage behind as well as the wireframe edges outlining your elements.

Since I know that we cut the tabletop portions of the "radar stations" to 30 inches wide and left them at their full 8 foot, plywood length, there is a base measurement to start with to build a reference object in your 3D application. In Figure 4.46 you can see two of these, laid end to end, to represent the two workstation countertops. Let's eyeball the height of these countertops and place them at about 27 inches (the height of my workstation desk, which seems about right). Next, using the camera VFX cues you can ascertain (discussed in Chapter 1), set your camera to a fairly wide focal length and place the camera's starting position at about 30 inches off the ground and approximately 10–12 feet away from the subject, as shown in Figure 4.46.

Align the wireframe with the counter at whatever point in the shot you choose. Remember, it's perfectly acceptable to work from beginning to end, end to beginning, middle forward and back, and so on. Keep in mind the information you can deduce from the scene—such as that the camera appears to be on a dolly so will likely translate in a straight line, even if it pans about on its Y axis. Move the camera in a straight line on its local axis until the end (or furthest point) of the shot and pan the camera until the counters and the wireframes align, as shown in Figure 4.47. Set your camera's first keyframe here.



**[Figure 4.46]** Camera placed at guesstimated starting height and position

**[Figure 4.47]** Camera aligned with scene element

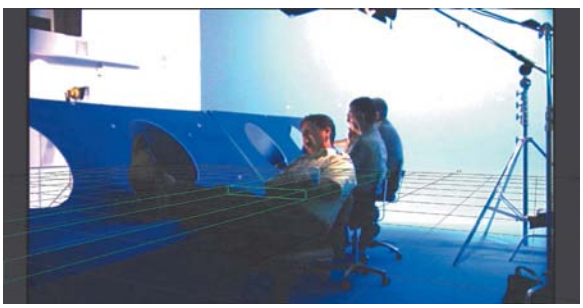
From here, it's the same procedure you followed for the hand 2D track, only in 3D. You will move your camera along the guesstimated path to the point where the 3D scene element you're tracking diverges the farthest from the wireframe before either beginning to return or changing directions. This will be your next keyframe position, and you will realign your camera until the stand-in and on-screen element are aligned, then set your next keyframe, and so on (Figure 4.48).

Then simply repeat this process until the wireframe and scene elements are locked throughout the duration of the shot.

Once this is completed, any object added to the scene—once composited and properly integrated, color corrected (covered in Chapter 5), and rendered—should composite and integrate nicely, follow the motion of the scene, and appear to actually exist within the scene, as shown in Figure 4.49.

**[tip]**

Make sure to move only your camera and only the way in which you believe the camera moved on set. Do not move the scene elements to match (unless they moved in real life) and do not move the camera in such a way that it didn't or wouldn't have moved on set.



**[Figure 4.48]** Camera aligned with scene element to next keyframe position

**[Figure 4.49]** Integrated 3D air traffic radar workstation set piece

## 3D Object Tracking

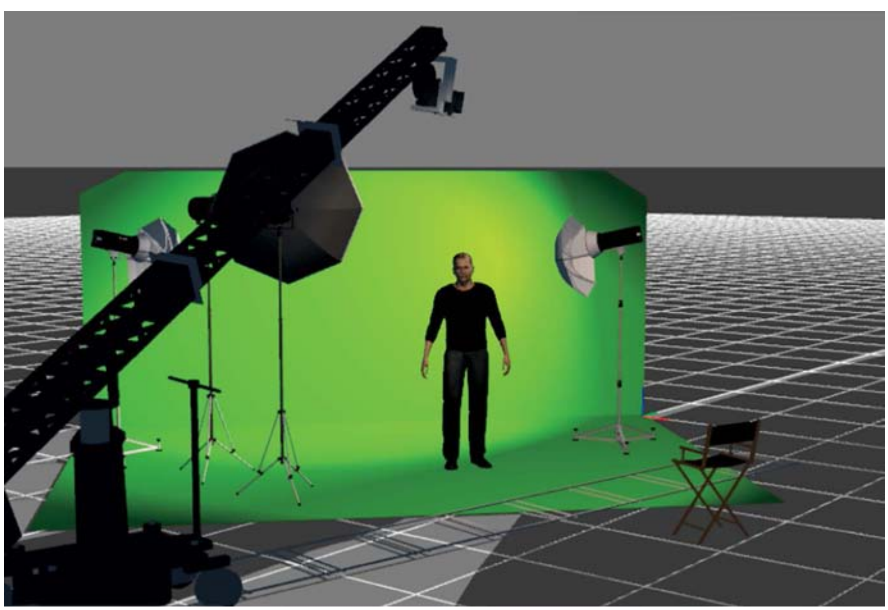
If we defined 2D *stabilization* as simply 2D motion tracking data of a piece of footage, inverted and applied back to that footage, you can think of the inversion of 3D camera motion track data as *object tracking*. Where the output of a 3D camera track is a static scene and a moving camera, the output of an *object track* is a static camera and a moving object or scene. This technique is particularly useful in cases such as adding 3D prosthetics or props to moving characters, covered in detail in Chapter 7.

## Motion Control and Motion Capture

Finally, no discussion of matching camera movements would be complete without discussing motion control and motion capture.

*Motion control* is the utilization of computer-controlled robotics (Figure 4.50) to very precisely create, record, and repeatedly play back camera movements over and over again. This allows for the combination of complex slow motion, or *replication shots*, such as adding clones of the same character to the same scene all within a continuous moving camera shot. On the pro side of this technique, motion control shots are very precise, align perfectly, and allow amazing seamless integrations. On the con side, motion control robots are expensive, huge, slow, and unwieldy and take a lot of time to set up, rehearse, and tear down.

**[Figure 4.50]**
3D illustration of a motion control camera rig



Similarly, *motion capture*, though not actually camera tracking either, is the capture of object motion data (as you would get with an object track) via various forms of data capture ranging from optical to wireless sensor arrays, as shown in Figure 4.51.

**[Figure 4.51]** Wireless motion capture sensor camera rig

Motion capture is mainly used for the recording of lifelike organic character motions and interactions, and although used extensively in VFX for 3D CGI character and digital doubles, it is more in the realm of 3D character animation than VFX and compositing.

Now that you understand the basics of VFX, 2D, and 3D, let's jump right in and begin integrating some CG VFX in Chapter 5.

# Index

## Numbers


1 + 1 = 3 (Eisenstein's Law), 9–10, 499
1 point tracks
- comparing good and bad targets, 128, 130–131
- Golden Rules, 127
- types motion trackers, 124–125

2 point tracks
- comparing good and bad targets, 129–130
- error amplification in, 132
- Golden Rules, 127
- live action background plate and, 179
- matchmoving and, 136–137
- types motion trackers, 125

2D
- 2D composite use in 3D, 323
- 3D objects moving in front of 2D planes, 326
- color space keyers, 111
- converting to 3D, 439
- crowd replication, 206–210
- displacement depth maps, 456
- face replacement, 210–214
- layer offset for 3D-like effects, 449–450
- matchmoving. *see* Matchmoving, 2D
- matte and roto, 105–108
- motion tracking. *see* Motion tracking, 2D
- texture displacement, 91–92
- visual effects, 104
- wire and rig removal, 104–105

2.5D
- atmosphere or aerial FX, 255–260
- camera movement, 339–342
- compositing, 323–327
- creating shadows and reflections, 192–195
- crowd replication, 206–210
- displacement FX, 272–277
- faking ambient occlusion, 263–267
- faking shadows and reflections, 191
- faking Z-depth, 267–271
- layer offset for 3D-like effects, 450–451
- overview of, 191, 255
- particle-based crowd replication, 411–414
- smoke and cloud FX, 260–263

2.5D matte painting
- adding elements to scene, 333–336
- complexity in, 343–348
- overview of, 333
- showing 2.5D elements in 3D space, 336–338

3D
- 2D composite in 3D space, 323
- 2.5D elements in 3D space, 336
- animation, 446–447
- applications for, 150–153
- camera solve, 156
- camera tracing, 228
- color space keyers, 112
- colored mesh data, 360, 363
- cove method for creating 3D set, 412–413
- cutting edge techniques. *see* Cutting edge 3D
- displacement depth maps, 456–459
- extractions, 466
- glasses, 435–437
- how 3D CGI is created, 143–150
- HUDs and, 304–305
- integrating 3D elements into 2D motion-tracked plate, 176
- matchmoving. *see* Matchmoving, 3D
- meshes, 488
- model substructures in digital destruction, 423–425
- motion tracking. *see* Motion tracking, 3D
- particle-based crowd replications, 414–418
- particle-based debris systems, 418–420
- photogrammetry, 228
- photography of 3D textures, 496
- Photoshop tools, 452–453
- re-lighting, 467–469
- for VFX, 143

3D Camera tool, Photoshop, 452–453
3D objects
- adding/rendering, 246
- color correction, 251–252

displacement of, 360–363
importing, 248–249
lighting to match footage and rendering, 249–250
loading into scene, 234
moving in front of 2D planes, 326
object tracking example, 246–247
placing, 234–236
quick reference, 495
replacing objects with other objects, 250–251
test objects for 3D motion tracking, 232–233
3ds Max, from Autodesk, 151
3DXchange, from Reallusion, 486
4 point cornerpin track, 126–127
8-bit images, 379
123D Catch, from Autodesk, 487–488
180-degree rule, line of action and, 19
180-degree shutter, 43–44
180-degree spherical image, 148


## A


Add mode, blend/transfer modes, 70
Additive blending, voxels and, 398
Adjustments layer, 448. *see also* Levels adjustment
Adobe After Effects. *see* After Effects
Adobe Photoshop. *see* Photoshop
Advanced techniques
2D motion tracking, 138–139
2.5D camera movement, 339–342
2.5D compositing, 323–327
2.5D digital matte painting, 343–348
camera projections, 348–354
digital environment applications, 354
digital matte painting and set extensions, 327–338
keyers, 113
overview of, 323
selection methods, 78–79
Terragen digital environment application, 354–355
virtual sets, 357–358
virtual studio, 358–364
Vue digital environment application, 354–355
World Machine digital environment application, 356
Aerial FX, 2.5D, 255–260
Aerial perspective, 183–184, 285
Aerial photo, adding object over aerial background, 256–257
After Effects
2D motion tracking, 133
3D motion tracking, 159–160
layer-based compositor, 110
Puppet tool, 339–341
roto tools in, 122
AI (artificial intelligence), 394–395
Aiptek 3D, 439
Alpha channels
applying lighting using alpha as texture, 92
checking matte foreground and background, 492
clipping elements in camera projections, 351–352
creating procedural light wraps, 203
holdout mattes, 68–69
matching truss alpha map, 217
premultiplied, 236
as selection method, 77–78
Alphanumeric HUDs, 302
Ambient lighting, setting intensity to 0%, 173
Ambient occlusion (AO), faking in 2.5D, 263–267
Anaglyph 3D glasses, 435, 445
Anaglyph stereoscopic 3D
black and white, 448
color, 447–448
example, 459
Analog formats, 59
Anamorphic aspect ratios and pixels, 61
Animation. *see also* Keyframes
3D, 446–447
camera projections and, 352–353
issues with HDRI IBL solutions, 382
matching. *see* Matchimation
rotoscope in cell animation, 116
showing 2.5D elements in 3D space, 336–337
traditional, 42
Animation Camera, 351–352
AO (ambient occlusion), faking in 2.5D, 263–267
Aperture, depth of field and field of view, 45–48
Applications
2D motion tracking, 132–134
3D, 150–153
3D motion tracking, 159–162
compositing, 109
digital environment, 354–356
fluid dynamics simulation, 404–407

Applications (*continued*)
roto, 122–123
selection, 84
virtual studio, 360
Artifacts
fine-tuning, 180
of speed (motion blur), 64
Artificial intelligence (AI), 394–395
Aspect ratios
formats and, 59
pixels, 61
quick reference, 495
screens, 61
Atmosphere FX
2.5D, 255–260
sky replacement and, 284
snow atmosphere, 301
Atmospheric attributes
fine-tuning, 180
identifying, 52–53
picking color for, 183–184
Auto track, how 3D motion tracking works, 155
Autodesk
3D applications, 150–151
123D Catch, 487–488
Averaging filters, for smoothing motion tracks, 158

## B

Back light (rim) light
placing, 175
in three point lighting, 15
VFX lighting and integration, 172
Background plates
2.5D matte painting, 333
adding to composite, 346
creating separation with foreground, 330–331
in digital matte painting, 327–330
making sure plates/elements are properly related, 493
moving foreground element of live action background, 179–180
in special effects shots, 65–66
tracking live action plate, 179
Background shots (BG)
adding computer generated imagery to, 7
compositing two images, 81–83
forced perspective and, 38–39
live composite (glass painting) and, 36
types of shots, 12
Basic integration VFX. *see* Integration techniques, basic
Beauty and restoration
digital beauty, 370
digital de-aging, 373–375
digital makeup and tattoos, 370–373
film coloration, 366–370
global illumination, radiosity, and image-based lighting, 376–379
high dynamic range images and light probes, 379–382
overview of, 365
smart-image-based lighting and light rig solutions, 382–384
studio lighting, 385–388
Best's Law, 500
Bezier curves
choosing which type of curve to use, 119
rotosplines and, 117–118
Billboards, 214, 400. *see also* Cards (3D planes)
Binary digits (bits)
8-bit images, 379
CRT control and, 54
data compression and, 56–57
Binary format, 56–57
Birth rate (generation rate), of emitters, 391–392
Bit per channel (bpc), image color and, 379
Bits (binary digits)
8-bit images, 379
CRT control and, 54
data compression and, 56–57
Black and white, anaglyph stereoscopic 3D, 448
Black and White tool, 448
Blacks. *see also* Shadows
checking densities, 492
checking element integration, 260
correcting in atmospheric effect, 258
creating gradients, 216
creating procedural light wraps and, 203–204
curves adjustment input, 288
curves adjustment output, 289
levels adjustment, 80, 86
matching shadow density, 181
Blender application
for fluid dynamics simulation, 407
open source 3D application, 153

Blend/transfer modes
applying light wraps to images, 205
applying to window areas of day-for-night scene, 296–297
bullet hits and, 432
complex and multisource operators, 69–70
in digital matte painting, 345
dirtying down surfaces, 91
film coloration and, 369
HUDs and, 305
muzzle flashes and, 429
Blocking, in movie scenes, 17–18
Blue color. *see* Red, green, and blue (RGB)
Blue sky, color temperature of, 50
Bluescreen
integrating into 2D motion-tracked plate, 176
keying, 81–83, 330
lighting, 177–178
pulling key extraction, 340
Bluescreen (BS) keyer, 81–83, 330
Blur effects
adding occlusion to crowd replication, 266
adding to cloaking effect, 276–277
adding to digital matte painting, 329
adding to grain/noise layer, 200
adding to heat distortion effect, 274
of bungee jumper, 308
compositor checklist, 493
creating procedural light wraps, 204–205
creating wave effect, 272
depth of field (DOF) and, 257
for digital de-aging, 374–375
levels adjustment, 87
particle-based crowd replication and, 414
softening mattes, 108
softening selection edges, 78
Boujou application, from Vicon, 159–160
Bounce lights. *see also* Fill light
3D light matching technique, 256
lighting greenscreen or bluescreen elements, 178
multi-pass rendering and compositing, 314
placing, 174
radiosity and, 379
Bounding boxes, layers and, 337
Box emitter, 391
Bpc (bit per channel), image color and, 379
Bread and butter FX
day-for-night scenes. *see* Day-for-night scenes
digital HUD (heads up display), 302–305
extraction sky replacement, 283–285
multi-pass rendering and compositing, 313–319
overview of, 279
reverse sky replacement, 280–282
sky replacements, 279–280
summer for winter, 297–302
time ramping, 310–313
wire and rig removal, 306–309
Brook's Law, 499
Brushes
creating billowing smoke effect, 262
creating custom, 300–301
Magic Wand Selection, 75
BS (bluescreen) keyer, 81–83, 330
B-spline curves
choosing which type of curve to use, 119
rotosplines, 118
Bullet dynamics, 403
Bullet hits, in digital destruction, 431–433
Bullet time
2.5D camera movement, 339
temporal motion effects, 33–34
Bump
creating lighting truss grid and, 218
working with grayscale images, 96
Bump maps
of moon, 472–473
working with grayscale images, 96
Burn maps, in hull burn effect, 426
Butterworth filters, for smoothing motion tracks, 158


## C


Camera projections
animating, 352–353
clipping elements using alpha channels, 351–352
geometry of, 349–350
overview of, 348–349
positioning and locking the camera, 350–351
textures and, 349
Camera solve
in 3D motion tracking, 156
in 3D object tracking, 247–248
in computer generated 3D motion tracking, 231–232
refining, 248

Cameras
- 2.5D camera movement, 339–342
- 3D camera tracking, 228
- attributes of, 43–45
- in-camera effects. *see* In-camera effects
- creating emotions, 17
- data, 496
- movement, 13–14
- placing, 241–242
- quick reference, 495
- reference images in motion tracking, 231
- shooting speeds, 39–41, 62
- shutters. *see* Shutters
- staging and blocking movie scenes and, 18
- stereoscopic, 439
- virtual, 358–359
- working with, 64

Candidates, in 3D motion tracking, 155
CAP-XYZ color space, 60
Cards (3D planes)
- in aerial photo, 258–260
- applying to bird example, 222–226
- grid technique, 214–219
- house of cards, 220–221
- overview of, 209
- for smoke and cloud effect, 260–261

Cards, 2D, 400
Career
- demo reel, 501–502
- goal setting, 504
- landing a job, 503
- rules for success, 505
- starting, 501

Cathode ray tube (CRT), 54, 62–63
CC. *see* Color correction (CC)
Cell animation, rotoscope in, 116
Center of gravity (COG), particle-based debris systems and, 418
CGI. *see* Computer generated imagery (CGI)
Channel ops, 80–83
Channel shift, for 3D-like effects, 449–450
Channel Shuffle, 267
Cheating, value of using shortcuts, 494
Chroma
- color terminology, 497
- keys. *see* Keyers/keying

Cinema 4D application, from Maxon, 152
Clark, Alfred, 22–23
Clean plate, 71
Clipping elements
- clipped colors, 60
- using alpha channels, 351–352

Clipping maps, in hull burn effect, 426
Cloaking effect, 276–277
Cloning
- order used in, 103–104
- overview of, 98–100
- randomness used in, 101–102
- techniques, tips, tricks, strategies, 101

Close-up shots (CU)
- of bungee jumper, 308
- types of shots, 10–11

Cloth simulations, 403–404
Cloud computing, 123D Catch using, 487–488
Clouds
- 2.5D, 260–263
- adding elements to scene, 336
- flopping cloud plate, 281

COG (center of gravity), particle-based debris systems and, 418
Color
- 2D color space keyers, 111
- 3D color space keyers, 112
- anaglyph stereoscopic 3D, 447–448
- checking with color pickers, 178, 366
- day-for-night scenes, 286–287
- depth, 58–60
- film coloration, 366–370
- key extraction in sky replacement, 283
- matching, 493
- RGB model. *see* Red, green, and blue (RGB)
- separation overlays. *see* Keyers/keying
- terminology, 496–497

Color blend mode, 369
Color Burn blend mode, 369
Color correction (CC)
- in 3D object tracking, 251–252
- for atmospheric effect, 260
- bullet hits and, 433
- creating procedural light wraps and, 203
- in digital matte painting, 329–333, 344
- displacement extraction and, 482
- fine-tuning, 180
- sky replacement and, 283–284
- for smoke and cloud effect, 262

Color maps, working with grayscale images, 95
Color Range tool, Photoshop, 79, 298
Color temperature
  color terminology, 497
  compositor checklist, 493
  of light sources, 49–50
  lighting and integration and, 172
Common effects. *see* Bread and butter FX
Complementaries, color terminology, 497
Component video, 60
Compositing
  2D visual effects, 104
  2.5D compositing, 323–327
  in 3D matchmoving example, 236–237
  adding object over background shot, 256–257
  applications, 109, 122
  checklist, 492
  cloning, 98–101
  grunge and grime maps in, 87–95
  keyers in, 111–114
  layer-based, 110
  map use in, 95–98
  matte and roto in, 105–108
  nodal-based, 110–111
  order used in cloning, 103–104
  overview of, 73, 108
  principles of composition, 20
  randomness used in cloning, 101–102
  Rejlander in history of, 28
  selection methods. *see* Selection methods
  slap comps, 283
  wire and rig removal, 104–105
Compositing, multi-pass
  determining needed passes, 313–314
  examples, 315–319
  overview of, 313
Compression
  color depth sampling and, 58–59
  data compression and, 56–57
Computer generated imagery (CGI)
  adding to real background, 7
  first use in films, 42
  how 3D CGI is created, 143–150
Computers, language of zeros and ones in, 53–54
Concepts, VFX
  complex and multisource operators (blend/transfer), 69–70
  extractions, 71
  layered-approach, 65–69
  overview of, 64
Cones, of eye, 286
Confidence levels, in 3D motion tracking, 156, 229
Contact shadow, 51
Continuity, of movie events, 19
Contrast
  adjusting, 273
  curves adjustment, 293
  sky replacement and, 283
Controls
  effect controls, 273
  layers and, 337
Convergence
  3D animation and, 447
  adjusting, 448
  stereoscopic 3D vision and, 438, 443–444
Core mattes
  compositor checklist, 492
  creating, 107
Core shadow, 51–52
Cove method, for creating 3D set, 412–413
Coverage (detailed) shots, 11
Crane
  in camera movement, 13
  example shot, 238–239
Crepuscular rays (godrays), 281–282
Cropping photos, rule of thumb, 11
Crowd replication
  2D and 2.5D shots, 206–210
  adding occlusion to, 264–267
  depth maps and, 270
  particle-based, 410
  particle-based 2.5D, 411–414
  particle-based 3D, 414–418
CRT (cathode ray tube), 54, 62–63
CU (close-up shots)
  of bungee jumper, 308
  types of shots, 10–11
Cubes, global illumination, 377
Cues, VFX
  camera, 43–45, 495
  depth and atmospheric, 52–53
  lens, focal length, depth of field, 45–48
  lighting, 48–50, 494
  media, 53
  overview of, 43
  shadows, 50–52

Curves adjustment. *see also* Splines
applied to day-for-night scene, 290, 294–295
displacement and, 457
how it works, 287–288
inputs, 288–289
outputs, 289
summer for winter scene, 299
Cutting edge 3D
123D Catch, 487–488
complex terrains using DEM and SRTM data, 474–478
displacement modeling, 470
extractions, 466
new technologies, 482
overview of, 461
Photoshop magic and, 462
procedural extraction using displacement, 478–482
procedural futuristic or space complex design, 470–474
Reallusion software, 483–487
re-lighting, 467–469
Ricoh Theta, 482–483
vanishing point photogrammetry, 462–465
X-cam and Paracosm, 488–491
Cyc (cyclorama), 240–243

## D

D4/D16, aspect ratios and pixels, 61
Darken mode, blend/transfer modes, 70
Data compression, 56–57
Data transfer, 55–56
Day-for-night scenes
complexity in, 291
creating mattes for elements in, 292
curves adjustment for color tones, 294–295
curves adjustment for scene elements, 287–290
gradient of darkness, 294
lighting adjustments, 296–297
overview of, 285–287
Daylight bulbs, color temperature of, 50
De-aging, digital, 373–375
Debevec, Paul, 379
Debris systems, particle-based 3D, 418–420
DEM. *see* Digital elevation model (DEM) data
Demo reel, 501–502
Depth. *see also* Z-depth
color depth, 60
identifying attributes of, 52–53
multi-pass rendering and compositing, 316
visual cues for, 20–22
Depth maps
2D displacement, 456–459
3D displacement, 360–362, 456–459
faking Z-depth and, 267–271
procedural and complex, 456
roto, 456
stereoscopic conversion and, 454–455
Depth of field (DOF)
blur effect, 257
camera lens and, 45–48
creating procedural light wraps and, 203
faking Z-depth technique for adding blur, 267–268
focal length and, 43
Destabilization, in 2D matchmoving, 137–138
Destruction, digital. *see* Digital destruction
Detailed (coverage) shots, 11
Dial HUDs, 303
Difference keys, 71
Difference mode
blend/transfer modes, 70
matchmoving and, 140–141
Diffuse channel
lighting truss grid example, 218
multi-pass rendering and compositing, 314, 316
pumpkin example, 149
Diffuse maps, working with grayscale images, 95, 98
Digital
beauty, 370
complex terrains using, 474–478
de-aging, 373–375
doubles for characters, 484
effects in films, 42
environments, 354–356
extractions, 71
makeup and tattoos, 370–373
matte painting. *see* Matte painting, digital
Digital destruction
3D model substructures, 423–425
blowing it all up, 422–423
bullet hits, 431–433
hull burn effect, 426–429

muzzle flashes and fake interactive lighting, 429–431
overview of, 419–422
Digital elevation model (DEM) data
creating, 476–477
examples, 478
resolution, 474–475
sources, 475
Digital formats
classifications of, 59
data compression and, 56–57
data transfer and, 55–56
sampling and, 58–59
Digital HUD (heads-up display)
creating a moving 3D HUD, 304–305
overview of, 302
types of, 302–304
Digital video (DV), 58–59
Displacement
of 2D textures, 91–92
of 3D objects, 360–363
depth maps and, 456–459
film coloration and, 367
modeling, 470
procedural extraction using, 478–482
pumpkin example, 150
working with grayscale images, 97
Displacement, in 2.5D
adding elements to scene, 334–335
cloaking effect, 276–277
heat effect, 274–276
water effect, 272–274
Displacement maps, 97
Distort tool
creating billowing smoke effect, 261–262
film coloration and, 367
Divide mode, blend/transfer modes, 70
Dolly shots
camera movement and, 13
forced perspective and, 24
Double exposure (superimpositions), 34–35
Drift
Golden Rules for motion tracking, 126
identifying possible problems in motion tracking, 233
Dry-for-wet setup, Méliès use of, 27–28
Dumb particles, 394
Dustbusting, cloning and, 98–99
DV (digital video), 58–59
DVCPRO HD, aspect ratios and pixels, 61
Dynamics
benefits of, 389
bullet dynamics, 403
fluid dynamics simulation, 404
overview of, 401
rigid body dynamics, 401–403
soft body dynamics, 403–404

## E

ECU (extreme close-up) shots, 10–11
Edge mattes
compositor checklist, 492
creating, 107–108
Edges, adjusting in vanishing point photogrammetry, 463–465
Edison, Thomas, 22–23
Edit Plane tool, 463
Eisenstein, Sergei, 9–10, 499
Eisenstein's Law, 9–10, 499
Element plate, in special effects shots, 65
Elevations. *see* Digital elevation model (DEM) data
Elliptical Marquee selection, 74, 76
Elliptical roto mask, 264–265
Emitters
3D particle-based crowd replication and, 415–416
3D particle-based debris systems and, 418
generating particles, 390–392
Emotion
camera motion creating, 17
shot emotion, 16–17
Energy weapon/effect
components of, 185–188
tips and tricks for, 189–190
Environments, advanced
2.5D camera movement, 339–342
2.5D compositing, 323–327
2.5D digital matte painting, 343–348
camera projections, 348–354
digital environment applications, 354
digital matte painting and set extensions, 327–338
overview of, 323
Terragen application, 354–355

Environments, advanced (*continued*)
virtual sets, 357–358
virtual studio, 358–364
Vue application, 354–355
World Machine application, 356
e-on software's Vue, 354–355
Eraser tool, 343–344
Error amplification, in 2 point tracks, 132
Establishing shots, 11
EWS (extreme wide shot), 10–11
Explosions
blowing it all up, 422–423
particle parameters, 394–395
particle-based debris systems and, 418–420
rigid body dynamics and, 401–402
Exposure
blending scenes and, 494
matting for multiple exposure, 41–42
Rejlander's use in compositing, 29
superimpositions (double exposure), 34–35
Expressions (mathematical), 180, 224
Extraction
3D, 466
adding occlusion to crowd replication, 264–265
clipping elements in camera projections, 351–352
creating solid white silhouette of, 269
in day-for-night scenes, 286–287
for digital matte painting, 344
mattes in, 105
procedural extraction of grunge and grime maps, 84–87
procedural extraction using displacement, 478–482
removing elements, 71
replacing objects with other objects, 250–251
sky replacement, 283–285
Extreme close-up (ECU) shots, 10–11
Extreme wide shot (EWS), 10–11
Eyeon Software's Fusion. *see* Fusion
Eyes
human vs. film and video, 62
physiology of, 286

## F

Face replacement, 2D, 210–214
Fade control, creating custom brushes, 300–301
Farvour's Law, 500
Feather Selection tool, 77–78
FG. *see* Foreground shots (FG)
Field of view (FOV), camera lens and, 46–47
Fill light
light matching techniques, 256
lighting greenscreen or bluescreen elements, 178
placing, 174
in three point lighting, 15
VFX lighting and integration, 172
Film
analog formats, 59
attributes of, 53
coloration, 366–370
vs. human eye, 62
matching grain of, 197–201
Film look, formats and, 62–63
Film plane attribute, 43
Film speed attribute, 44
Filters
blur effects and, 78
for in-camera effect, 30–31
displacement and, 91–92
heat distortion effect and, 274
mattes, 108
for smoothing motion tracks, 158, 248
FinePix REAL 3D W3 cameras, 439
Fire effect, adding to objects, 251–252
Flags, for blocking lighting, 173
Flickering animation, issues with HDRI IBL solutions, 382
Flopping the line, 19
Flopping the plate, 281
Flowline application, 407
Fluid dynamics simulation
other applications, 407
overview of, 404
RealFlow application for, 404–405
TurbulenceFD application for, 405–406
Flying cameras, 14
Focal length, camera lens and, 45–48
Focal plane, camera attributes, 43
Follow and continue technique, in cloning, 104
Force effectors, particles, 396

Forced perspective
  Méliès use of, 24
  in photography of miniatures, 38–39
Foreground
  creating separation between background and foreground, 330–331
  turning off lights in, 174
Foreground plates
  in digital matte painting, 327–330
  making sure plates/elements are properly related, 493
  in special effects shots, 66
Foreground shots (FG)
  compositing two images, 81–82
  moving foreground element of live action background, 179–180
  types of shots, 12
Formats
  analog and digital, 59
  data compression and, 56–57
  data transfer and, 55–56
  DEM and SRTM data, 474
  film look and, 62–63
  human eye vs. film and video, 62
  overview of, 53–55
  resolution and aspect ratios, 59–61
  sampling and, 58–59
Foundry's Nuke. *see* Nuke
FOV (field of view), camera lens and, 46–47
Fps. *see* Frames per second (fps)
Fracturing, rigid body dynamics and, 401–402
Frame rate
  film and, 64
  media attributes and, 53
Frames
  film cameras and, 62
  in time ramping, 310–311
Frames per second (fps)
  camera attributes and, 44
  high speed, 32
  normal speed, 31
  shooting speeds, 62
Free move, camera motion, 229
Freeform drawing, with Lasso Selection tool, 75
Fuji FinePix REAL 3D W3 cameras, 439
Fusion
  2D motion tracking, 133
  from Eyeon Software, 414
  roto tools in, 122


## G


Gamma level
  checking densities, 492
  checking for element integration, 260
  curves adjustment, 288
  depth maps and, 271
  levels adjustment, 80
  matching midtones, 182
Garbage mattes
  adding occlusion to crowd replication, 264–265
  compositor checklist, 492
  creating, 106–107
  crowd replication and, 207–208
  procedural light wraps and, 202–203
Gauge HUDs, 303
Gaussian Blur
  adding noise to grain/noise layer, 200
  levels adjustment, 87
  softening selection edges, 78
Generation rate (birth rate), of emitters, 391–392
Geometry
  of camera projections, 349–351
  creating 3D, 326
  multi-pass rendering and compositing, 316
  volume voxels in creating imaginary, 399
Ghost effects, 34–35
Glasgow's Laws, 500
Glass matte painting (live composite), 36–37
Global illumination (GI)
  of 3D model, 381–382
  defined, 380
  example, 382
  overview of, 376–379
Glossiness, of 3D sphere, 147–148
Glossiness maps, 96
Glow effects, adding to objects, 251–252
Glow maps, 95
Goal setting, 503
Godrays (crepuscular rays), 281–282
Golden Spirals, composition guidelines, 20
Go-motion technique, computer-controlled movement, 40
Google Project Tango, 491
Grabel's Law, 500
Grade adjustment, using with displacement, 457
Gradient tool, Photoshop, 215–216

Gradients
- adding to matte painting, 347
- of atmospheric dust, 413
- of color grade, 346
- of darkness, 294
- in day-for-night scenes, 290, 294
- film coloration and, 367
- snow atmosphere, 301

Grain
- compositor checklist, 493
- correcting in matte painting, 333
- digital de-aging and, 375
- film look and, 64
- film/video attributes, 53
- fine-tuning, 180
- matching, 197–201
- moving, 201
- sky replacement and, 284
- wave effect in water, 272

Gravity parameter, particles, 394–395

Grayscale images
- displacement and, 272
- textures and, 95–97

Green color. *see* Red, green, and blue (RGB)

Greenlighting, getting approval in moviemaking, 5

Greenscreen
- crowd replication and, 207
- example, 250
- integrating into 2D motion-tracked plate, 176
- lighting and, 177–178

Grime maps
- magical uses of, 87–95
- procedural extraction of, 84–87

Grunge maps
- magical uses of, 87–95
- procedural extraction of, 84–87

Gutterson's Laws, 500

## H

Hair light, in three point lighting, 15

Hand off, staging and blocking movie scenes and, 18

Hand tracking. *see* Matchimation

Hard body dynamics, 401–403

Harmonious Triangles, composition guidelines, 20

HD. *see* High definition (HD)

HDRI. *see* High dynamic range images (HDRI)

HDV (high definition video), 61

Heads-up display (HUD). *see* Digital HUD (heads-up display)

Heat effect, 274–276

Hiding errors/problems, 494

High definition (HD)
- color depth sampling and compression, 58–59
- digital video, 59
- film look and, 62

High definition video (HDV), 61

High dynamic range images (HDRI)
- defined, 381
- overview of, 379–380
- solutions to issues with, 382–383

High speed (slow motion), temporal motion effects, 31–32

Highlights. *see also* Whites
- correcting in atmospheric effect, 258
- levels adjustment, 80
- matching, 181–182
- placing, 175
- in three point lighting, 15
- VFX lighting and integration, 172

Holdout mattes, 68–69

Hotspots. *see* Specularity (hotspot/shininess)

Hue
- color terminology, 496
- day-for-night scenes, 286–287
- sky replacement and, 283–284

Hue Correct tool, 455

Hue/Saturation adjustment
- creating black and white anaglyph stereoscopic 3D, 448
- for day-for-night scene, 292–294
- desaturating a map, 85
- desaturating colors, 336
- summer for winter scene, 299

Hull burn effect
- 3D model substructures, 424–425
- digital destruction, 426–429

Human vision. *see* Eyes

Hypertextures, 399

Hypervoxels, in LightWave, 398

## I

IBK (Image Based Keyer), in Nuke, 113

IBL. *see* Image-based lighting (IBL)

iClone software, from Reallusion, 483–487

Idea, moviemaking starting with, 4–5
Image Based Keyer (IBK), in Nuke, 113
Image cloning. *see* Cloning
Image-based lighting (IBL)
  3D stone totem model, 381–382
  defined, 380
  example, 382
  overview of, 377–379
  Ricoh Theta for, 482–483
  smart-image-based lighting, 382–384
Images
  8-bit, 379
  HDRI, 379–380
Imagineer System's Mocha Pro. *see* Mocha Pro
In the can, completion of shooting, 7
In-camera effects
  filters, 30–31
  matte painting, 35–37
  miniatures, 38–41
  single-pass, 30
  superimpositions (double exposure), 34–35
  temporal motion, 31–34
Indicator HUDs, 303
Insert shots, 12
Integration techniques, advanced
  2D and 2.5D crowd replication, 206–210
  2D face replacement, 210–214
  applying card technique to bird example, 222–226
  card grid technique, 214–219
  creating procedural light wraps, 202–206
  house of cards, 220–221
  matching grain and noise, 197–201
  overview of, 197
Integration techniques, basic
  2D motion tracking, 176–184
  components of energy weapon or effect, 185–188
  creating roto-based effects, 185
  creating shadows and reflections, 192–195
  energy effects, 189–190
  faking shadows and reflections, 191
  lighting, 172–173
  overview of, 171
  techniques for element lighting, 173–176
Intensity, color terminology, 496
Interaction controls, particles, 394
Interactive lighting
  compositor checklist, 493
  faking, 429–431
Interlacing, 62–63
Intermediates, color terminology, 497
Invisible effect, sky replacements as, 279
Isolated roto matte, 122

## J

Jawset Visual Computing's TurbulanceFD application, 405–406
Jib
  example shot, 238–239
  types of camera movement, 13
Jitter
  in camera solve, 248
  identifying possible problems in motion tracking, 233
Jobs. *see also* Career
  categories in VFX, 501
  landing, 503
Jolly, Matt, 431–432

## K

Kelvin, Lord William, 49–50
Kelvin scale, 50
Key light
  2D color space, 111
  adding occlusion to crowd replication, 264–265
  creating looks and emotions with, 16
  lighting and integration and, 172
  lighting greenscreen or bluescreen elements, 177–178
  in multi-pass rendering and compositing, 314
  placing, 174
  in three point lighting, 14–15
Keyers/keying
  2D color space, 111
  3D color space, 112
  advanced, 113
  bluescreen (BS), 81–83, 330
  color terminology, 497
  isolated roto for, 122
  overview of, 111
  self-matting and, 106
  wire and rig removal, 306

Keyframes. *see also* Animation
- applying to bird example, 223
- blocking camera movement into, 18
- displacement map, 273
- heat distortion effect, 274
- muzzle flashes and, 430
- for smoke and cloud effect, 261–262
- in time ramping, 313

Kicker, in three point lighting, 15
Kinect, from Microsoft, 491
Kinetoscope parlors, 22


## L


Landscape generation software, 356
Lansam's Law, 500
Lasso Selection, Photoshop, 74–76
Latitude, film look and, 64
Layers
- layer-based compositors, 109–110
- natural parallax motion, 338
- thinking in, 65–69
- without bounding boxes or controls, 337

Lens
- focal length and depth of field, 45–48
- quick reference, 495

Lens flares
- added to bird example, 225
- adding to hull burn effect, 427–428
- benefits of, 494
- preventing, 175

Letter shapes, staging and blocking movie scenes and, 17–18
Levels adjustment
- crushing levels to get high-contrast, trackable features, 239
- DEMs and, 476
- depth maps and, 271
- face replacement and, 212
- Hue/Saturation, 85
- overview of, 79–80
- procedural extraction using displacement, 480
- shadow densities, 260
- softening mattes, 108

LG Thrill smartphone, 439
Life Time (frame), particles, 392
Light Based on Image Tool Conversion Helper (Light B.I.T.C.H.), 383
Light boxes, for studio lighting, 385
Light probes
- example, 382
- HDRI and, 380–381
- overview of, 379–380

Light rig solutions, 382–384
Light spill contamination, 173
Light wrap
- creating procedural, 202–206
- defined, 197
- mattes, 201
- sky replacement and, 284

Lighten mode, blend/transfer modes, 70
Lighting
- 3D light matching technique, 249–250, 256
- 3D re-lighting, 467–469
- attributes, 48–50
- basic integration techniques, 172–176
- compositor checklist, 493
- creating procedural light wraps, 202–206
- in day-for-night scenes, 296–297
- faking interactive, 429–431
- film-like effects, 64
- filters and, 30–31
- global illumination, 376–379
- greenscreen or bluescreen elements and, 177–178
- image-based. *see* Image-based lighting (IBL)
- for looks and emotions, 16
- multi-pass rendering and compositing, 314, 316
- quick reference, 494
- reference, 381
- smart-image-based lighting, 382–384
- spotlight effect, 92
- studio lighting, 385–388
- three point lighting, 14–15
- of virtual set, 357–358

LightWave, from New Tek
- 3D application, 151
- 3D virtual studio, 360
- hypervoxels in, 398
- particle systems and, 390

Line of action, 19
Linked 3D geometry-based particle systems, 401
Linus's s Law, 500
Liquid effects, 398

Live composite (glass matte painting), 36–37
Lock
- checking and locking 3D objects, 235–236
- positioning and locking the camera, 350–351
- still, locked off, on sticks camera movement, 13

Lossless compression, 57
Lossy compression, 57
Low lights, creating looks and emotions, 16
Low speed, temporal motion effects, 32
Luma mattes, creating procedural light wraps, 205
Luminance
- isolated roto for keying, 122
- mattes, 205
- sky replacement and, 283
- working with grayscale images, 95

Luminosity
- color terminology, 497
- multi-pass rendering and compositing, 316

Luminosity maps, working with grayscale images, 95
Luxology's Modo 3D application, 152

## M

Magic Wand Selection
- Color Range selection compared with, 79
- Photoshop selection methods, 75
- selecting black areas with, 217

Magnetic Lasso tool, 75
Makeup, digital, 370–372
Map (picture-based) HUDs, 304
Maps
- 3D, 147
- burn maps and clipping maps in hull burn effect, 426
- compositing and, 95–98
- depth maps. *see* Depth maps
- displacement map, 272–273
- grunge and grime maps, 84–87
- occlusion maps, 263

Markers, placing tracking markers, 243–245
Marketing yourself, 503
Marquee Selection, Photoshop, 74–76
Mask tools, 229–230
Masks, sky replacement and, 280–282
Master shots, 11
Matchimation, 2D
- overview of, 139–141
- wire and rig removal, 307

Matchimation, 3D
- adding/rendering 3D objects, 246
- checking orthogonal and perspective views, 242
- constructing three -walled cyc and rough model of objects, 240
- crushing levels to get high-contrast, trackable features, 239
- example from *Balloon* film, 237–238
- hand tracking and, 162–165
- overview of, 237
- placing camera, 241–242
- placing tracking markers, 243–245

Matchmoving, 2D
- destabilization, 137–138
- overview of, 136–137
- stabilization, 137

Matchmoving, 3D
- checking and locking 3D objects, 235–236
- compositing and, 236–237
- loading 3D objects into scene, 234
- magic of, 228
- motion control and motion capture, 166–167
- moving foreground element of live action background, 179
- object tracking, 166
- overview of, 162, 233

Matte painting
- day-for-night scenes, 290–291, 294
- examples, 37
- history of, 35
- live composite (glass painting), 36
- Méliès use of, 27
- tips, 497–498

Matte painting, digital
- 2.5D scene, 333
- adding blinds and fake shadows, 331–332
- adding elements to 2.5 scene, 333–336
- adding window reflection elements, 331
- background and foreground plates, 327–330
- complex 2.5D digital matte painting, 343–348
- creating separation between background and foreground, 330–331
- grain and color correction pass, 333
- showing 2.5D elements in 3D space, 336–338

Mattes
- compositing and, 105–108
- core mattes, 107

Mattes (*continued*)
- creating for day-for-night scene, 292
- creating for sky replacement, 280–282
- in day-for-night scenes, 294–296
- edge mattes, 107–108
- fine-tuning, 108
- garbage mattes, 106–107
- holdout mattes, 68–69
- keying, 122
- light wrap mattes, 201
- loading, 83
- for multiple exposure, 41–42
- overview of, 105
- rotoscoping, 116–117
- self-matting, 106
- in summer for winter scene, 298–299

Maxon's Cinema 4D application, 152

Maya application
- from Autodesk, 150
- plugins, 360

MD (midground shots), 12

Media attributes, identifying, 53

Medium shots (MS), 10–11

Méliès, Georges
- dry-for-wet setup, 27–28
- effect examples, 25–26
- forced perspective, 24, 38–39
- in history of visual effects, 23
- live composite (glass painting), 36
- matte painting, 27
- multiple pass exposures, 35
- substitution effect, 24, 422

Merge to HDRI Pro, Photoshop, 381

Meshes
- 3D, 488
- 3D-colored mesh data, 360, 363
- creating, 340
- creating 3D models, 143, 145
- film coloration and, 367
- rigid body dynamics and, 402–403

Microsoft's Kinect, 491

Midground shots (MD), 12

Midtones. *see* Gamma level

Miniatures
- camera speed and, 39–41
- forced perspective, 38–39
- photography of, 38

Mirror technique, Rejlander's use in compositing, 28

Mocap plugin, from Reallusion, 486–487

Mocha Pro, from Imagineer System
- 2D motion tracking, 134
- 3D motion tracking, 161
- digital makeup and tattoos, 370–372
- film coloration and, 369
- Remove tool, 371
- roto application, 122–123

Modeling
- creating 3D models, 143, 332
- displacement modeling, 470
- in three point lighting, 14

Modo, from Luxology, 152

Moore's Law, 499

Motion blur
- adding to crowd replication, 413–414
- adding to heat distortion effect, 274–275
- adding to hull burn effect, 427–428
- applying to bird example, 223
- artifacts of speed, 64
- compositor checklist, 493
- defined, 45
- media attributes and, 53
- particle-based debris systems and, 421

Motion capture, 3D matchmoving, 166–167

Motion control
- 3D matchmoving, 166–167
- camera movement and, 14
- particles, 392

Motion effect, adding to digital matte painting, 347

Motion pictures
- in history of VFX, 498–499
- shooting speeds, 62

Motion pictures, making
- the idea, 4–5
- pitch-viz, pre-viz, and post-viz, 5–7
- pre-production, production, post-production, 5–7
- writing the concept, 5

Motion pictures, principles of
- 180-degree rule, 19
- camera movement, 13–14
- composition, 20
- continuity, 19
- Eisenstein's Law, 9–10
- manipulating time and space, 20
- overview of, 7–8
- parallax, 20–21
- parallel action, 20
- persistence of vision, 8–9

perspective, 21–22
screen direction, 19
shot emotion, 14–17
shots, 10–12
staging, letter shapes, and blocking, 17–18
VFX pipeline and, 4–7
Motion tracking, 2D
1 point tracks, 124–125
2 point tracks, 125
4 point cornerpin track, 126
advanced strategies, 138–139
anatomy of motion tracker, 124
applications for, 132–134
basic integration techniques, 176–184
comparing good and bad targets, 128–131
comparing with 3D, 154
Golden Rules, 126–127
overview of, 123
rotation and scale error amplification, 132
tracker assisted roto, 134–135
types of, 124
using 2D automated mass track for 3D tracking, 229–230
when to use, 227
Motion tracking, 3D
applications for, 159–162
camera solve, 231–232
confidence levels, 229
magic of, 228
overview of, 153–155
placing test objects, 232–233
techniques, 155–158
using 2D automated mass track for 3D tracking, 229–230
when to use, 227
Movement, camerawork and, 64
Movies. *see* Motion pictures
MS (medium shots), 10–11
Multiple pass
combination or solid result, 35
photography, 40
rendering and compositing, 313–319
transparent or ghost effects, 34–35
Multiply blend mode
bullet hits and, 432
film coloration and, 369
overview of, 70
Murphy's (Sod's) Law, 500
Muzzle flashes, in digital destruction, 429–431

## N

Newtek's LightWave. *see* LightWave
Next Limit Technologies' RealFlow application, 404–405
Nodal-based system
compositors, 109–111
creating particle-based shadows, 414
Node-flow, 110
Noise
adding to heat distortion effect, 274
in camera solve, 248
digital de-aging and, 375
filling solid with monochromatic, 272
film/video attributes, 53
Golden Rules for motion tracking and, 126
issues with HDRI IBL solutions, 382
issues with motion tracking, 233
moving, 201
Non-rendering helper object/layer. *see* Nulls (non-rendering helper object/layer)
Non-rendering nulls, particle systems, 396–397
Normal maps, working with grayscale images, 96
Normal speed, temporal motion effects, 31
NTSC, aspect ratios and pixels, 61
Nuke, from Foundry
2D motion tracking, 133
3D motion tracking, 159–160
digital de-aging, 374
Image Based Keyer (IBK), 113
nodal-based compositor, 110
roto tools in, 122
stereoscopic conversion and, 455
Nulls (non-rendering helper object/layer)
3D HUDs and, 304
moving foreground element of live action background, 180
overview of, 396–397
in particle systems, 390
placing 3D objects, 234–236
placing tracking markers, 244–245

## O

Object tracking, 3D
adding effects (shadows, fire, smoke, glow), 251–252
camera solve, 247–248
color correction, 251–252
example, 246–247

Object tracking, 3D (*continued*)
- final product, 253
- importing 3D objects into scene, 248–249
- lighting 3D objects to match footage and rendering, 249–250
- matchmoving and, 166
- overview of, 246
- replacing objects with other objects, 250–251

Objects
- adding object over aerial background, 256–257
- adding/rendering for matchimation example, 246
- checking and locking 3D objects, 235–236
- constructing rough model in matchimation example, 240
- displacement of 3D objects, 360–363
- importing 3D objects into scene, 248–249
- lighting 3D objects to match footage and rendering, 249–250
- loading 3D objects into scene, 234
- matching, 197–201
- moving 3D objects in front of 2D planes, 326
- null objects, 390
- placing test objects for 3D motion tracking, 232–233
- quick reference for 3D, 495
- replacing objects with other objects, 250–251
- test objects in, 158

Occipital Structure Sensor, 491

Occlusion
- depth cues, 52
- faking ambient occlusion, 263–267
- of light, 263

Occlusion maps, 263

One shot, two shots., 10

Opacity
- adding occlusion to crowd replication, 266
- alpha channels and, 78
- blending scenes and, 494
- face replacement and, 212
- lowering for realistic film coloration, 369
- sky replacement and, 280

Opacity maps, 96

Opacity slider, 91

Operators, complex and multisource (blend/transfer), 69–70

Optical flow, in time ramping, 312

Optical printing extractions, 71

Order, used in cloning, 103–104

Organic modeling, 144

Orthogonal views
- camera solve and, 231
- checking in matchimation example, 242

OTH (over-the-hip shots), 12

OTS (over-the-shoulder shots), 11–12

Over cranking, camera speed, 31–32

Over process, holdout mattes, 68

Overlap. *see* Occlusion

Overlay mode, blend/transfer modes, 70

Over-the-hip shots (OTH), 12

Over-the-shoulder shots (OTS), 11–12


## P


Paint
- 2D paint for wire and wig removal, 104–105
- stripping, 89

PAL, aspect ratios and pixels, 61

Pan, types of camera movement, 13

Paracosm, 488–491

Parallax
- natural parallax motion, 338
- showing 2.5D elements in 3D space, 336
- stereoscopic 3D vision and, 438, 442
- visual cue for depth, 20–21

Parallel action, manipulating time in movies, 20

Parallel viewing, stereoscopic 3D vision and, 440–444

Parents, using in placing 3D objects, 235

Particle Resistance, 392

Particle Size, 392

Particle systems
- components of, 390
- emitters, 390–392
- linked 3D geometry-based, 401
- null objects, 390
- particles, 392–396
- partigons and non-rendering nulls, 396–397
- sprite-based rendering, 400
- uses of, 409
- voxels in rendering, 397–399

Particle Weight, 392

Particle-based crowd replications
- 2.5D, 411–414
- 3D, 414–418
- overview of, 410

Particle-based debris systems
3D, 418–420
hull burn effect and, 427–428
Partigons, 396–397
Paul, Robert W., 42
Penumbra, faking shadows and reflections, 191
Persistence of vision, principles of motion pictures, 8–9
Perspective
aerial, 258, 285
checking perspective views, 242
compositor checklist, 493
forced perspective, 24, 38–39
visual cue for depth, 21–22
PFTrack, from Pixel Farm
3D motion tracking application, 159
Mask tools, 229
Phone negotiation, 503
Photogrammetry
3D, 228
3D motion tracking based on, 154–155
123D Catch using, 487–488
vanishing point photogrammetry, 462–465
Photomerge function, Photoshop, 307
Photoshop
3D tools, 452–453
Color Range selection, 79
creating black and white anaglyph stereoscopic 3D, 448
creating burn maps, 426
creating color anaglyph stereoscopic 3D, 447–448
creating custom brushes, 300–301
creating lighting grid, 215–216
creating mid-gray solid, 199
curves adjustment tool, 287–288
Lasso Selection, 74–75
Magic Wand Selection, 75
magical uses of, 462
Marquee Selection, 74–75
Merge to HDRI Pro, 381
overview of, 74
Photomerge function, 307
Vanishing Point tool, 462
versatility of, 73
Pickwhip tool, 180
Picture-based (map) HUDs, 304
Pipeline
multi-pass rendering and compositing and, 313
VFX, 4
Pitch-viz
in moviemaking, 5
Reallusion iClone software and, 484
Pixel Farm's PFTrack. *see* PFTrack
Pixel flow, in time ramping, 312
Pixels
2D motion tracking and, 123
Magic Wand Selection, 75
Planar tracking, 134
Planetside Software's Terragen, 354–355
Plates, thinking in layers and, 65–66. *see also* by types of plates
Point cloud
in 3D motion tracking, 157
dense mapped, 490
placing test objects for 3D motion tracking, 232–233
virtual studios, 360, 363
Point lights
3D re-lighting, 467–469
lighting greenscreen or bluescreen elements, 178
Point of view (POV)
forced perspective and, 24
of particle position, 420–421
realism and, 326
re-lighting and, 467
Points, in 3D CGI, 143–145
Polygonal Lasso tool, 75–76
Porter, Edwin S., 41
Post-production, in moviemaking, 7
Post-viz
in moviemaking, 6–7
Reallusion iClone software and, 484
POV. *see* Point of view (POV)
Pre-production
Méliès' use of pre-production art, 23
in moviemaking, 5–6
Pre-scored clothing, bullet hits and, 432
Pre-viz
3D space shot, 326
in moviemaking, 5–6
Reallusion iClone software and, 484
virtual studios and, 358
Primaries, color terminology, 497
Primatte color space keyer, 112
Problem-solving, 409
Production, in moviemaking, 6
Progressive, film cameras shooting in, 62

Project Tango, Google, 491
Projection Camera, 350–352
Pulfrich, Carl, 453
Pulfrich effect, 453–454
Puppet tool, After Effects, 339–341
Pyrotechnic destruction, 423

## Q

Quick reference, for VFX artists, 495–498
Quick Selection tool, 75

## R

Rack focus, staging and blocking movie scenes and, 18
Radiosity
- in 3D model, 381–382
- defined, 380
- example, 382
- mimicking, 384
- overview of, 377–379
- re-lighting and, 469
- studio lighting and, 385–388

Randomness
- applying to bird example, 224
- in cloning, 101–102
- of particles, 393–394

RAW camera, 379
RealFlow application, from Next Limit Technologies, 404–405
Reallusion
- 3DXchange, 484, 486
- iClone, 484
- Mocap plugin, 486–487

Rectangle, creating for lighting truss grid, 217–218
Rectangular Marquee selection, 74, 76
Red, green, and blue (RGB)
- adjusting levels, 183
- advanced 2D tracking strategies, 138–139
- alpha channels and, 77
- anaglyphs and, 447
- channel adjustment in face replacement, 212–214
- color depth and, 60
- compositing two images, 81–82
- creating procedural light wraps and, 203–204
- curves adjustment, 290, 294–295
- multi-pass rendering and compositing, 314, 316
- video images and, 58

Reference images
- in 3D motion tracking, 231
- film coloration and, 366–367

Reference points, for camera projections, 351
Reflections
- 2.5D, 191
- adding to 2.5 scene, 335
- adding window elements, 331
- card method of creating, 192–193
- compositor checklist, 493
- projection method of creating, 194–195
- studio lighting and, 385–386
- working with grayscale images, 95

Reflective gradient, creating with Photoshop, 216
Refraction maps, 96
Rejlander, Oscar G., 28–30
Remove tool, Mocha Pro, 371–372
Rendering
- issues with HDRI IBL solutions, 382
- virtual sets, 357–358

Rendering, multi-pass
- determining needed passes, 313–314
- examples, 315–319
- overview of, 313

Rendering particle systems
- partigons and non-rendering nulls, 396–397
- sprite-based rendering, 400
- voxels, 397–399

Re-photography effects, 42
Replacement. *see also* Extraction
- 2D face replacement, 210–214
- 3D, 246–253
- extraction sky replacement, 283–285
- reverse sky replacement, 280–282
- sky replacement generally, 279–280

Replication
- of birds into flock, 224
- in creating lighting truss grid, 218

Replication shots, motion control and motion capture, 166–167
Resistance parameter, particles, 393–394
Resolution
- comparing formats, 62
- DEMs, 474–475
- formats and, 59–61
- full-resolution color, 58

Restoration. *see* Beauty and restoration

Reverse
day-for-night FX, 286–287
sky replacement, 280–282
temporal motion effects, 33
RGB. *see* Red, green, and blue (RGB)
Ricoh Theta, 482–483
Rigid body dynamics, 401–403
Rigs
light rig solutions, 382–384
removing wires and rigs, 104–105, 306
stereoscopic, 439
virtual, 358–359
Rim (back light) light
placing, 175
in three point lighting, 15
VFX lighting and integration, 172
RLE (run length encoding), 57
Rods, of eye, 286
Roget, Peter Mark, 8
Rotation distortion, creating billowing smoke effect, 261–262
Rotation parameter, particles, 394
Roto
advanced spline features, 119
applications for, 122–123
applying mask to isolate heat distortion effect, 274–276
applying mask to isolate water effect, 273–274
Bezier curves, 117–118
B-spline curves, 118
bungee jumper example, 308–309
choosing which type of curve to use, 119
clipping elements in camera projections, 351–352
compositing and, 105–108
compositor checklist, 493
creating mattes, 116–117
creating roto-based VFX, 185
in day-for-night scenes, 290–291
depth maps and, 456
elliptical roto mask, 264–265
extraction using, 283, 344–345
Golden Rules for, 119–121
keying with isolated roto, 122
Mask tools and, 229–230, 250
overview of, 116
removing wires and rigs, 105
rotospline types, 117
in summer for winter scene, 299
tracker assisted, 134–135, 370
Roto energy weapon/effect
components of, 185–188
tips and tricks for, 189–190
Rotosplines
advanced spline features, 119
Bezier curves, 117–118
B-spline curves, 118
bungee jumper example, 308
choosing which type of curve to use, 119
for digital de-aging, 374
for isolating background for film coloration, 366–369
for selecting windows, 292
types of, 117
Rubber sheet method, 3D displacement, 456–459
Rule of Thirds, composition guidelines, 20
Run length encoding (RLE), 57

## S

Sampling, 58–59
Sampling noise, issues with HDRI IBL solutions, 382
Saturation. *see also* Hue/Saturation adjustment
color terminology, 496
day-for-night scenes, 286
desaturate a map, 85, 94
extraction sky replacement and, 283
Scale
adding object over aerial background, 256–257
adding to digital matte painting, 347
camera projections and, 350
displacement maps and, 273
in photography of miniatures, 39
Scanline VFX's Flowline application, 407
Scatter setting, creating custom brushes, 300–301
Scene reference, 496
Screen depth, stereoscopic 3D vision and, 442
Screen direction, continuous and congruent movement, 19
Screen mode, blend/transfer modes, 70
Screen sizes, quick reference, 495
Script, continuity of, 19
Scripts, nodal-based compositors, 110
Scrolling HUDs, 303
SD (standard definition), 59
Secondaries, color terminology, 497
Sections, composition guidelines, 20

Selection methods
- advanced, 78–79
- alpha channels, 77–78
- applications of, 84
- channel ops, 80–83
- for elements of summer for winter scene, 298
- Lasso Selection, 74–75
- levels adjustment tool, 79–80
- Magic Wand Selection, 75
- Marquee Selection, 74–75
- in Photoshop, 74
- procedural extraction of grunge and grime maps, 84–87
- VFX and, 76–77

Self Interaction controls, particles, 394
Self-matting, 106
Set Channels tool, 269
Sets
- creating 3D, 324–325, 412–413
- extensions, 327–338
- virtual, 357–358

Shade
- color terminology, 496
- multi-pass rendering and compositing, 316

Shaders, 3D textures and, 147
Shadows. *see also* Blacks
- adding effects to objects, 251–252
- adding occlusion to crowd replication, 264–267
- card method of creating, 192–193
- components of, 51–52
- compositor checklist, 493
- correcting in atmospheric effect, 258
- direction, intensity, and quality of light and, 50–51
- faking, 191, 331–332, 430
- fill lights and, 174
- levels adjustment, 80
- lifting densities, 260
- matching densities, 181
- multi-pass rendering and compositing, 316
- particle-based, 414
- projection method of creating, 194–195
- VFX lighting and integration, 172

Shake, roto tools in, 122
Shape Dynamics panel, creating custom brushes, 300–301
Shininess. *see* Specularity (hotspot/shininess)
Shooting schedule, establishing in pre-production, 6
Shooting speeds, 62
Shots
- background plate, 65
- framing, 498
- lighting, 14–15
- types of, 10–12

Shutters
- camera attributes and, 43–44
- changing angle of, 413–414

Shuttle Radar Topography Mission (SRTM), 474
sIBL (Smart-image-based lighting), 382–384
Side lights, creating looks and emotions with, 16
Silhouette roto application, 122–123
Simulation
- applications for, 404–405
- benefits of, 389
- bullet dynamics, 403
- fluid dynamics simulation, 404–407
- particle systems. *see* Particle systems
- rigid body dynamics, 401–403
- soft body dynamics, 403–404

Single-pass effects, 30. *see also* In-camera effects
Size
- camerawork and, 64
- media resolutions and, 59–60
- Particle Size, 392
- screen size reference, 495

Sky replacements
- extraction sky replacement, 283–285
- overview of, 279–280
- reverse sky replacement, 280–282

Slap comp, of extraction sky replacement, 283
Smart particles, RealFlow application, 394, 404–405
Smart-image-based lighting (sIBL), 382–384
Smith, G.A., 42
Smoke
- 2.5D, 260–263
- adding effects to objects, 251–252

Smooth filters, 248
Soft body dynamics, 403–404
Soft light mode, blend/transfer modes, 70
Space, designing futuristic complex, 470–474
Space, manipulating in movies, 20
Spatter brush, creating burned out or demolished look with, 343–344
Specularity (hotspot/shininess)
- of 3D sphere, 147
- breakup, 95–96, 98, 149

multi-pass rendering and compositing, 314, 316
working with grayscale images, 97
Specularity maps, 95, 98
Spheres
3D modeling, 147–148
global illumination, 377
Spin parameter, particles, 394
Spinning light rig, 384
Spline warp tool, 367
Splines. *see also* Rotosplines
in 3D CGI, 144–145
in face replacement, 214
Spotlights, 92, 178
Sprites
defined, 400
sprite-based particles, 414
sprite-based rendering, 400
Squibs, bullet hits and, 432
SRTM (Shuttle Radar Topography Mission), 474
stabilization
2D motion tracking, 137, 166
camera inversion creating, 246
face replacement and, 211
Staging, movie scenes, 17–18
Standard definition (SD), 59
Steadicam, camera movement and, 13
Stereo window, 442
Stereograph, 436, 438
Stereoscopic 3D
3D animation and, 446–447
creating, 439–445
creating 3D glasses, 436–437
creating black and white anaglyph stereoscopic 3D, 448
creating color anaglyph stereoscopic 3D, 447–448
history, background, and core concept, 436–439
layer offset for 3D-like effects, 449–451
overview of, 435
Photoshop 3D tools, 452–453
Pulfrich effect for creating, 453–454
stereoscopic cameras and camera rigs, 439
Stereoscopic conversion, 2D to 3D
depth maps and, 456–459
faking Z-depth technique for, 267–268
overview of, 454
technology and implementation, 454–455
Still, locked off, on sticks
2D motion tracking and, 123
types of camera movement, 13
Stop action (stop motion)
history of visual effects in film, 23
Méliès use of, 24
temporal motion effects, 32
traditional animation and, 42
Storyboards, 23
Stripping paint and surfaces, magical uses of grunge and grime maps, 89
Studio lighting, 385–388
Studios, virtual, 358–364
Stunt doubles, 210
Subdivision surface modeling, 144
Substitution effect, 24, 422
Subtract mode, blend/transfer modes, 70
Success, rules for, 505
Summer for winter
adding key visual cues, 299–302
adjusting hue/saturation, 299
curves adjustment for snow simulation, 299
extracting elements for, 297–298
lighting adjustments, 296–297
overview of, 297
Sun/sunlight
3D light matching technique, 256
godrays, 281–282
simulation of, 224
Superimpositions (double exposure), 34–35
Surface voxels, 398
Surfaces
in 3D CGI, 143
in 3D modeling, 147
stripping, 89
Sweet spot, for camera projections, 349
SynthEyes, 161

## T

Target HUDs, 303
Tattoos, digital, 372–373
Technologies, new
123D Catch, 487–488
overview of, 482
Reallusion software, 483–487
Ricoh Theta, 482–483
X-cam and Paracosm, 488–491

Temporal motion effects
- bullet time, 32–34
- high speed (slow motion), 31–32
- low speed, 32
- normal speed, 31
- overview of, 31
- reverse, 32
- stop frame, 32
- time lapse, 32

Terragen, from Planetside Software, 354–355
Terrains, complex terrains using DEM and SRTM data, 474–478
Test objects, in 3D motion tracking, 158
Textures
- 3D, 147
- camera projections and, 349
- dirtying down, 90–91
- displacement of 2D, 91–92
- hypertextures, 399
- lighting applied using alpha as texture, 92
- photography of 3D, 496
- procedural futuristic or space complex design, 471–473
- of virtual set, 357

Three point lighting, 14
Threshold functions, creating burn maps and, 426
Thrill smartphone, from LG, 439
Tilt, types of camera movement, 13
Time, manipulating in movies, 20. *see also* Temporal motion effects
Time lapse, temporal motion effects, 33
Time ramping
- adding keyframes, 312–313
- optical flow (pixel flow) and, 311–312
- overview of, 310
- tween frames in, 310–311

Tint, color terminology, 496
Toeing in, stereoscopic 3D vision and, 440–444
Tolerance, Magic Wand Selection, 75, 217
Top lights, creating looks and emotions with, 16
Tracker assisted roto, 134–135, 370
Tracking. *see* Motion tracking
Transfer modes. *see* Blend/transfer modes
Transition shots, 12
Transitive relations, 243
Translucency maps, 96
Transparency
- alpha channels and, 78
- multiple pass exposures, 34–35
- working with grayscale images, 96–98

Transparency maps, 96, 98
Triangles, composition guidelines, 20
Triggers, in particle generation, 392
Truck, types of camera movement, 13
Tungsten lights, color temperature of, 50
Turbulence parameter, particles, 393
TurbulenceFD application, from Jawset Visual Computing, 405–406
Tween frames, in time ramping, 310–311

## U

UDK (Unreal Development Kit), 358
Ultimatte keyer, 113
Umbra, faking shadows and reflections, 191
Undercranked, camera speed, 32
Underwater (UW)
- dry-for-wet setup, 27–28
- shots, 14

Unreal Development Kit (UDK), 358

## V

Vanishing Point Clone tool, 100
Vanishing point photogrammetry, 462–465
Vanishing Point tool, Photoshop, 462
Velocity parameter, particles, 393–395
Vertices, in 3D CGI, 143–145
VFX
- career and job categories, 501
- important movies in history of, 498–499
- laws, 499–500
- Méliès role in origins of, 23–28
- origins of, 22
- Rejlander role in origins of, 28–30
- truism, 501

Vibration parameter, particles, 393
Vicon motion tracking application, 159
Video
- analog and digital formats, 59
- vs. human eye, 62
- matching video noise, 198–201
- shooting speeds, 62

Video stock, attributes of, 53
Video Toaster, from New Tek, 151
Virtual cameras, 358–359
Virtual sets, 357–358
Virtual studios
  3D-colored mesh data, 360, 363
  applications for, 360
  displacement of 3D objects, 360–363
  equipment in, 359
  overview of, 358
  point cloud data, 360, 363
Volume voxels, 398–399
Voodoo motion tracking application, 162
Voxels
  rendering particle systems, 397–399
  sprite voxels, 400
  TurbulanceFD application, 405–406
Vue, from e-on software, 354–355

## W

Water effect
  adding elements to 2.5 scene, 335
  displacement effect, 272–274
Wheatstone, Sir Charles, 436
Whites. *see also* Highlights
  checking densities, 492
  checking for element integration, 260
  correcting in atmospheric effect, 258
  creating gradients, 215
  creating procedural light wraps and, 203–204
  creating solid white silhouette of extraction, 269
  curves adjustment input, 289
  curves adjustment output, 289
  levels adjustment, 80, 86–87
  matching highlights, 181–182
Wide shots (WS), 10–11
Wire
  removing wires and rigs, 104–105, 306
  window method, 306–309
Wireframe view
  3D camera view, 244
  alignment of objects in, 249
  box preview, 224
  changing views, 477–478
  composed in 3D application, 326
  of depth map, 267
  of explosion of building model, 401–403
  for matching foreground plate, 328
  rendering models in, 304–305
  selecting easy-to-see-through views, 241
  setting 3D model to, 164–165
  shaded view, 327–328
  of virtual set, 357
World Machine, 356
Wrapped, completion of shooting, 7
Writing, creating concept for movie, 5
WS (wide shots), 10–11

## X

X-cam, 488–491
X-Spline, in digital makeup, 371
XYZ coordinate system
  in 3D CGI, 143
  camera solve and, 232
  motion tracking and, 154
  particle-based debris systems and, 418

## Y

Y Pb Pr color space
  color depth and, 60
  sampling and compression and, 58
Yatchum, Jeff, 429

## Z

Z-depth
  3D motion tracking and, 153–154
  for atmospheric effect, 257
  cloning and, 101
  faking, 267–271
  sky replacement and, 284
  for smoke and cloud effect, 262–263
  working with grayscale images, 97
Zoom, types of camera movement, 13
Z-space
  adding object over aerial background, 257
  crowd replication and, 410–411
  motion tracking and, 127, 131
  moving atmospheric effect into, 271
  offset in, 221
  particles emitters spinning into, 400
  pushing objects into, 209
  pushing planes into, 218–220, 257
  pushing smoke effect into, 262
  scaling objects and, 153