

The HDRI Handbook

High Dynamic Range Imaging for Photographers and CG Artists

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Table of Contents

8 Foreword

10 Introduction

- 11 About the author and contributors
- 12 Your road map



1



14 Chapter 1: The Background Story

- 15 1.1. Basic Questions
- 22 1.2. How We See the World
- 24 1.3. How Real Is Analog Photography?
- 28 1.4. Digital Images
- 38 1.5. Output Media



2

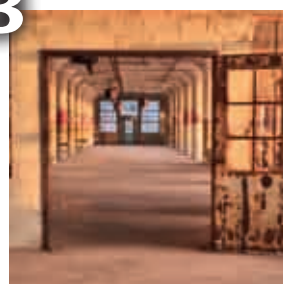


40 Chapter 2: New Tools

- 41 2.1. File Formats
- 61 2.2. Comparison of HDR Image Formats
- 64 2.3. HDRI Software



3



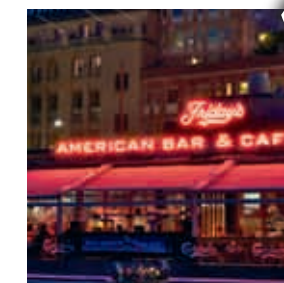
92 Chapter 3: Capturing HDR Images

- 93 3.1. Digital Imaging Sensors
- 101 3.2. Handiwork

144 Chapter 4: Tone Mapping

- 145 4.1. Hello Operator?
- 168 4.2. Tone Mapping Practice
- 172 4.3. HDR for Practical Fine Art Photography
- 183 4.4. Creative Tonemapping Techniques

4



212 Chapter 5: HDR Image Processing

- 213 5.1. Taking Advantage of the Full Dynamic Range
- 227 5.2. Effect Filters the More Effective Way

5



234 Chapter 6: Shooting Panoramic HDR Images

- 235 6.1. Pano Lingo
- 241 6.2. One-Shot Technique
- 243 6.3. Mirror Ball
- 258 6.4. Segmental Capture
- 280 6.5. Skydomes
- 285 6.6. Comparison

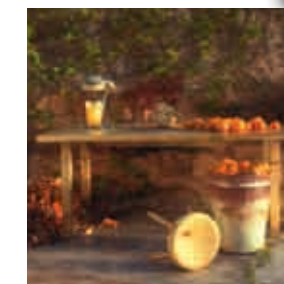
6



286 Chapter 7: Application in CGI

- 287 7.1. Principles of Computer-Generated Imaging
- 297 7.2. Brute Force Simulation: A Feasibility Study
- 302 7.3. Advanced Setup Techniques
- 323 7.4. Smart IBL
- 329 7.5. More Creative Applications

7



343 Last page

Though one could argue that the image is a human invention, high dynamic range is not. Light spans an enormous range, and our eyes can adapt from the dim level of a starlit night to intense daylight, spanning over eight orders of magnitude (100 million to 1). This is comparable to the energy difference between getting going on a bicycle and taking off in a jumbo jet.

With this kind of range in real-world illumination, how have we gotten by so long with image contrast ratios of less than 100 to 1? The answer is deceptively simple. Although the range of light is enormous, our brain cares most about reflectance, and its range is comparatively modest. In fact, it is very difficult to create a surface that reflects less than 1% of the light it receives, and reflectances over 100% are forbidden by conservation of energy. Since the brain is trying to figure out surface reflectances based on what it sees, the huge range of illumination is often more of a hindrance to perception than a help. Therefore, an artist who skillfully removes the excess dynamic range in a painting is actually doing your brain a favor, making it easier for you to see what he (or she) sees. Skill and practice are required to accomplish this feat, for a painter who is inexperienced and does not know how to create the illusion of range within the limited reflectances available will create something more like a cartoon than a rendition. Realistic painting techniques were perfected by the Dutch masters during the Renaissance and are little practiced today.

Photography poses a similar problem in a different context. Here, we have the ability to record an image equivalent to that which lands on your retina. Starting from a negative,

skill is once again required to render a positive that captures what matters to the brain within the limited reflectances of a black-and-white or color print. For scenes that contain little dynamic range to begin with, nothing needs to be done and the whole process can be automated. For more challenging subjects, such as storm clouds over mountains or the shadowed face of a child in the sunshine, the darkroom technique of burn-and-dodge is indispensable. With this method, either a round obstructer on a stick is used to “dodge” overexposed regions or a piece of cardboard with a hole cut out is used to “burn” underexposed regions during enlargement. This is an arduous, manual process that requires considerable talent and experience to achieve good results. The move to digital cameras has made such exposure adjustments even more difficult due to their limited dynamic range, which is one reason professional photography has been so slow to migrate from film.

High dynamic range imaging (HDRI) enables the centuries-old practices of renowned artists in a new, digital arena. HDRI permits photographers to apply virtual burn-and-dodge techniques in their image editing process, leaving as little or as much to automation as they wish. Digital artists using HDRI are able to create virtual worlds that are as compelling as the real world since the physics of light can be simulated in their full glory. Using physically based rendering and image-based lighting, HDR photography and virtual scenes and objects may be seamlessly combined. This is common practice for mainstream productions in special effects houses around the world, and even television studios are getting into the act. Enthusiasts, both professional

and amateur, are also pushing the envelope, and commercial software, shareware, and freeware are available to assist the transition from a traditional imaging and rendering pipeline to HDRI.

Of course, not everyone needs HDRI. If the starting point is low dynamic range and the ending point is low dynamic range, there is little need for HDR in between. For example, a graphic artist who creates on a digital canvas and prints his work on paper gains no immediate benefit since reflection prints are inherently low dynamic range. It may be easier using existing tools to simply stick to printable colors and create the desired “look” using a conventional WYSIWYG paradigm. In the long run, even such an artist may enjoy features and effects that HDRI enables, such as lens flare and the like, but these will take time to reach the mainstream. Meanwhile, there is much for the rest of us to explore.

In this book, Christian Bloch introduces the topic of high dynamic range imaging and how it relates to the world of computer graphics, with an emphasis on practical applications. Starting with film photography, Mr. Bloch re-examines the digital image, looking at file formats and software for storing and manipulating HDR images and going on to discuss how such images can be captured using conventional digital cameras. This is followed by a description of tone-mapping operators that can transform HDR images into something viewable and printable on conventional devices. Then, a more complete discussion of HDR image editing introduces color in the larger context of illumination rather than simple reflectance. A chapter covering the specialized topic of HDR panorama capture

and reconstruction then leads into the final chapter on computer graphics imaging and rendering, describing the techniques that have revolutionized the film industry.

Whether you are an artist, a hobbyist, a technician, or some exotic mixture, these pages offer valuable explanations, methods, and advice to get you started or to take you further on the path of high dynamic range imaging.

GREG WARD OF ANYHERE SOFTWARE

This book will reveal the many secrets behind high dynamic range imaging (HDRI).

You have heard this term before, and maybe you have even worked with a high dynamic range image before. The simple fact that you are holding this book in your hand shows that HDRI is not all that new to you. But still, you want to know more. You want to know the full story, and I know exactly why.

Currently, there is a lot of talk about high dynamic range imaging in the online photography communities. The topic emerged from discussions about taking better pictures in difficult lighting conditions, and it turned out that HDRI is just the right tool to address this challenge. But HDRI is much more.

To cut a long story short: **High dynamic range imaging is a method to digitally capture, store, and edit the full luminosity range of a scene.** We are talking about all the visible light here, from direct sunlight down to the finest shadow details. Having all that available in one image opens the door for immense opportunities in postprocessing. HDRI is a quantum leap; it is just as revolutionary as the leap from black-and-white to color imaging. Or, for a more suitable analogy, HDRI is to a regular image what Dolby surround sound is to mono tape. If you are serious about photography, you will find that high dynamic range imaging is the final step that puts digital ahead of analog. The old problem of over- and underexposure—in analog photography never fully solved—is elegantly bypassed. HDRI extends the digital development process beyond anything that was ever possible in an analog darkroom. Correct exposure is not an on-site decision anymore; it becomes a flexible parameter that can be dealt with in entirely new ways. An HDR image is like a digital negative on steroids, more like a true representation

of the scene than a mere photographic image. You can even take measurements of true world luminance values in an HDR image. For example, you can point at a wall and determine that it reflects sunlight equal to 40,000 cd/m². Even better, if the HDR image is panoramic, you can apply all the captured light to 3D objects.

High dynamic range imaging is an emerging field, but it is not all that new anymore. It has become a mature technology. It has just been poorly documented. Until now.

Five years ago, HDRI was a huge buzzword in the world of computer graphics (CG). It was considered the holy grail of true photo-realism, the magic “make it cool” button that everyone was looking for. Fully digitally generated images were popping up, and even professionals could not tell if they were photographs or not. Hollywood studios were the first to adapt and implement that technology because their daily business is to fool the audience and sell them artificial dream worlds as the real thing. By now, HDRI has become a standard tool, even for the 3D hobbyist at home. Everyone and his dogs know how to use HDR images to make a rendering look photo-realistic. When they watch the **Making Of** feature for the latest blockbuster movie and the art director talks about lighting all the computer graphics with HDRI, everyone is nodding his head, mumbling, “Ah, sure... so that’s why it looks so good.” But what is really behind this technology? How can an HDR image be used as a light source? It’s just an image, isn’t it? How does it work? And can you make an HDR image yourself? Exactly how would that be done?

Many questions are still open, even for the 3D folks who have been using HDRI for years. Because **using** something is different from

understanding something. Only if you really understand the nature of HDRI will you be able to develop your own way of working with it. That’s why this book digs deeper than a footnote or a single chapter in a software-specific tutorial book. Reading it from cover to cover will build a comprehensive knowledge base that will enable you to become really creative with HDRI. Regardless of whether you are a photographer, a 3D artist, a compositor, or a cinematographer, this book is certain to enlighten you.

About the author and contributors

Your hosts on this journey to new frontiers of Digital Imaging are renowned artists, working professionally in the field for years. They speak your language, and they understand that a hands-on tutorial is a thousand times more valuable to you than scientific formulas.

Christian Bloch is a visual effects artist, who works and lives in Hollywood, California. During the six years of his professional career, he has created effects for the TV shows *StarTrek: Enterprise*, *Smallville*, *Invasion*, *Lost*, *24*, and *Studio 60* as well as for several movies and commercials. His work has been rewarded with an Emmy Award as well as a nomination for the Visual Effects Society Award. He has been a pioneer in the practical application of HDRI in postproduction, specifically under the budgetary and time restraints of TV production.

Bloch earned a degree in multimedia technology. Years of research and development went into his diploma thesis about HDRI, which was honored with the achievement award of the University of Applied Sciences

Leipzig. Since his thesis was published online in July 2004, it has been downloaded more than 15,000 times, and it has been established as the primary source of information on HDRI in Germany. This book is the successor to Bloch’s diploma thesis, rewritten completely from the ground up in English and heavily expanded and updated.

But this book is not just a one-man-show. There are many specialty applications for high dynamic range imaging. To provide you with the best expert knowledge available, Bloch has invited renowned experts to share their practical experiences and their secret workflow tricks.

Dieter Bethke has more than 17 years of experience in digital media production and does artistic photography, showing his prints at several galleries in Germany. When Bethke discovered HDRI, he turned into a diligent promoter in the photography community, and he believes that the future of digital imaging is high dynamic.

He also works as a consultant for digital fine art printing, prepress, color management, and digital photography. Bethke offers his expert knowledge in training seminars to media companies and individuals. He also contributed to the German localization and manual of *Photomatix*, which has been a remarkable resource for the photographic community.

Bernhard Vogl is one of Vienna’s finest panorama photographers. He has a long history of sharing his knowledge with the community through online tutorials, thus he has given countless photographers a jump start in the art and craft of panoramic photography. His particular interest in HDRI is a natural progression toward capturing even more of



▲ **Christian Bloch**

[PHOTO: TORE SCHMIDT]



▲ **Dieter Bethke**



▲ **Bernhard Vogl**

[PHOTO: MICHAEL WIESAUER]

“The Real Thing”. Just as a panorama breaks the framing restrictions of photography, a panoramic HDRI breaks free from exposure restrictions. For Vogl, this is the next step for capturing the moment and preserving it in a digital VR environment.



▲ Uwe Steinmüller

Uwe Steinmüller is known to the photography scene as the owner and chief editor of DigitalOutbackPhoto.com, one of the largest and most valuable resources on digital fine art photography. Originating from Germany, he moved to California in 1997, where he focused on the digital workflow, raw file processing, and fine art printing. He has written a number of books, two of which won the prestigious German Photography Book Award in 2004 and 2005.

Steinmüller’s engagement in HDRI evolves out of the never ending journey after the perfect print, and he is fascinated by the new opportunities to take total control over his digital pictures.

I am proud to present this book as a complete guide to high dynamic range imaging. You can read it from front to back, and I highly recommend you do so. However, many chapters are intended for browsing or for situations in which you are working with HDRI and you must quickly look something up. You may need to make a choice about image formats or you may be stuck doing a specific task and want to peek at a tutorial again. Let this book be your crib sheet. It’s full of practical hints and tips, software tests, workshops, and tutorials. There’s an old German saying that goes “Knowledge means knowing where it’s written.” Well, it’s all written here. That is all you need to know.

Your road map



Chapter 1 is an in-depth explanation of the ideas and concepts behind high dynamic range imaging.

This chapter is the foundation on which everything else is built. To understand the full range of opportunities, we must question some very basic concepts of digital and analog photography. You will be amazed to find out what little progress digital imagery has made until now and how a simple twist on the basic premise of digital—on the bits and bytes—can suddenly push it beyond the boundaries of what has been ever thought to be possible in analog.



Chapter 2 presents all the tools needed for a high dynamic workflow. Conventional image formats

have proven to be insufficient, and conventional software is still quite limited when dealing with HDR images. I will introduce and compare new image formats and programs, rate them, and give advice on how to integrate them into your own workflow. This chapter is also most useful as a quick reference that will come in handy on a million occasions.



Chapter 3 is all about capturing HDR images. You get to know both: the scientific way and the easy way. I will walk you through different methods and compare the results so you can choose the method that best suits your own situation. Also, we take a peek into some research labs and learn about the future of taking HDR images. It’s only a question of time before high dynamic range will be the standard and not the exception. So let’s look ahead to be prepared for tomorrow’s standard.



Chapter 4 is dedicated to tone mapping. You’ll be introduced to automatic algorithms as well as creative methods to reduce the tonal range of an HDR image while preserving all the details. This chapter is especially designed for all you photographers, because here is where you learn to create superior prints from HDR images. There is no right or wrong here; there is only creative potential to be explored. To inspire you in finding your own ways, Uwe Steinmüller and Dieter Bethke will showcase their personal workflow in practical tutorials.



Chapter 5 reveals new opportunities for image editing and compositing. You will see a wide variety of workshops that can easily be re-created with the material on the supplied DVD-ROM. The results will be compared to those of traditional methods. Learn how the pros used to work with HDRI to create more lifelike composites for film and television. There is an great wealth of established techniques that can easily be applied to still image editing as well.



Chapter 6 is dedicated to panoramic HDR photography, which is a cornerstone of this book because this is where the worlds of photography and computer graphics come together. And indeed, Bloch and Vogl contributed equally to this chapter. Together, they show you several different ways of shooting panoramic HDR images; they compare them all and rate them based on the necessary workload, equipment expense, and quality of the results. Chapter 6 is full of practical tips and tricks that will be an invaluable help in the field.



Chapter 7 finally demonstrates how HDR images can be used in 3D rendering. I will break down the technical background for you so you understand how rendering algorithms work and how you can make them work better for you. Step-by-step, you will find out what the ideal lighting setup looks like. Then I’ll take it a step further and present a brand-new lighting toolkit that automates the most common HDRI setup. On top of that, I’ll show you some unconventional applications that will encourage creative uses of HDRI.



All of the methods described in this book are based on readily available software that you can buy in a store or sometimes even find as freeware. They run on standard platforms such as Windows and Mac OS X, preferably both. It is very important to me that you have a chance to follow each workshop step-by-step. That is why proprietary in-house software and command-line programs are not covered here, even if they have proven successful in production for some privileged postproduction companies. The main goal is to make HDR working methods accessible to everyone, so friendly software with a graphical user interface is always preferred over scripting methods.