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ct Digital Photography

DVD
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StudioLine Photo Classic
PhotoAcute Studio

Video Tutorial
Adobe PS Elements 9

eBook
The Glossary of
Digital Photography

Photo Tools

Geotagging Your Photos

GPS cameras, accessories, software

Better Images with Optical Filters

Pro Lighting Effects The best studio setups

Mid-range Rivals

Camera Test

Canon, Nikon, Olympus, Sony

Extreme Subjects

Bursting bubbles, Space Station

Photoshop Elements 9

Should you update? With video tutorial

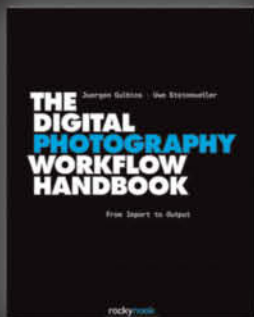
Noise-free in Low Light

Image stacking tricks explained

Travel Photography

Getting the most from your trip
Equipment and shooting tips





Juergen Gulbins · Uwe Steinmueller

The Digital Photography Workflow Handbook

From Import to Output

November 2010, 544 pages
978-1-933952-71-0, 8 x 10 Hardcover
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NK Guy

Mastering Canon EOS Flash Photography

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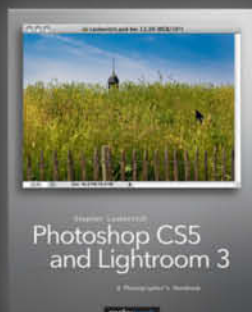
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Helmut Kraus · Uwe Steinmueller

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March 2010, 240 pages
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US \$ 34.95, CAN \$ 41.95

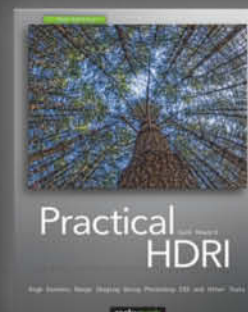


Stephen Laskevitch

Photoshop CS5 and Lightroom 3

A Photographer's Handbook

July 2010, 289 pages
978-1-933952-67-3, 8 x 10 Softcover
US \$ 39.95, CAN \$ 49.95

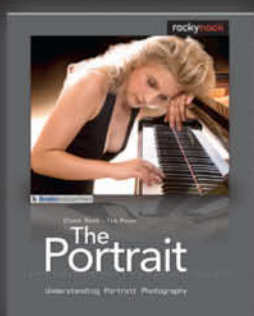


Jack Howard

Practical HDR, 2nd Edition

High Dynamic Range Imaging Using Photoshop CS5 and Other Tools

August 2010, 240 pages
978-1-933952-63-5, 8 x 10 Softcover
US \$ 34.95, CAN \$ 43.95



Glenn Rand · Tim Meyer

The Portrait

Understanding Portrait Photography

December 2009, 200 pages
978-1-933952-46-8, 8 x 10 Softcover
US \$ 34.95, CAN \$ 41.95



Uwe Skrzypczak

Wildlife Photography

On Safari with Your DSLR: Equipment, Techniques, Workflow

June 2010, 236 pages
978-1-933952-56-7, 8 x 10 Softcover
US \$ 39.95, CAN \$ 49.95



Cyrill Harnischmacher, Editor

The Wild Side of Photography

Unconventional and Creative Techniques for the Courageous Photographer

July 2010, 224 pages
978-1-933952-51-2, 10 x 8 Softcover
US \$ 29.95, CAN \$ 37.95

The sky's the limit!

Digital photography is here to stay and enriches our lives almost daily in new and fantastic ways.

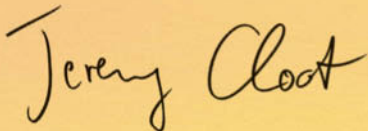
This issue of c't Digital Photography takes you all the way from the microcosmos contained in a single exploding soap bubble to the International Space Station – mankind's first foothold on the way to the stars.

Back on Earth, our piece on travel photography will help you get the most out of the photos you take on the road, while our in-depth look at GPS and geotagging gives you the low-down on pinpointing image locations and using geodata to catalog your work and discover more about the places you visit.

For the purists out there, we show you how to use accessory filters to fine-tune the look of your photos, and our lighting feature gives you a close-up view of the techniques used by pro studio photographers to capture perfect portraits.

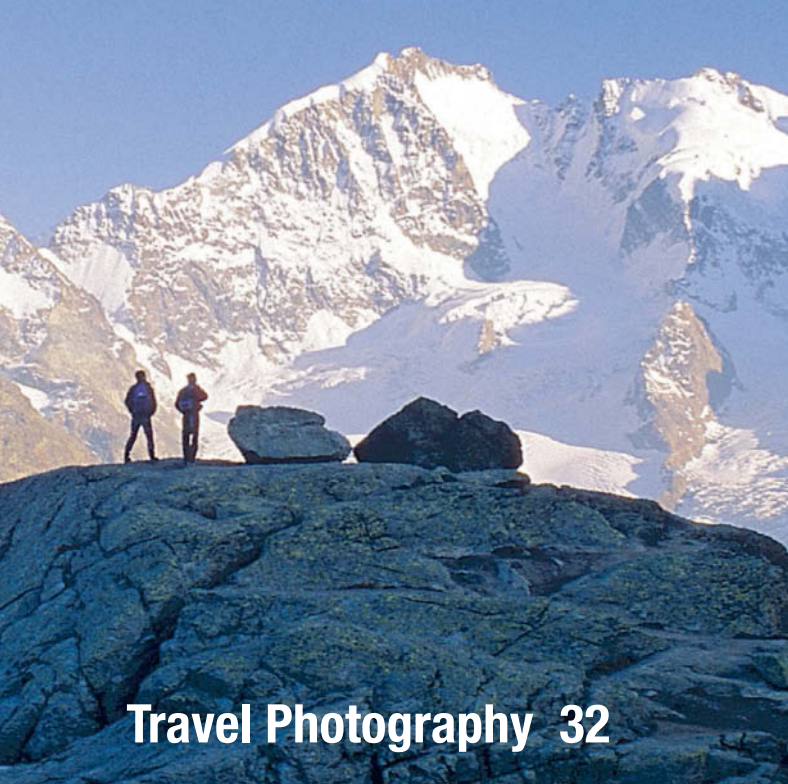
If all this gets you itching to get out and start shooting, our camera test gives you all the information you need to choose the right camera from the latest models to hit the market and – last but by no means least – this issue's portfolio by Lukas Roth straddles the fine line between fact and fantasy, with subtly tweaked images that leave you wondering if things are perhaps not quite what they seem.

Happy imaging and until next time ...



Jeremy Clout





Travel Photography 32



Geotagging Your Photos 50

Portfolio

Lukas Roth creates new worlds from hundreds of original photos. His images show people and places that appear to exist but which are, in reality, a subtle and compelling product of the photographer's imagination.

8 Lukas Roth Portfolio

Pro Lighting Effects

Art director and photographer Thomas Saur uses detailed descriptions and a wealth of real-world examples to demonstrate how different lighting techniques and compositional rules influence the look of a studio portrait.

16 Studio Lighting Tips

Travel Photography

Refining your travel photography technique produces better results and helps you to get more from your trip. Pro reportage and travel photographer Reinhard Eisele explains what equipment to use and how to capture fantastic images of people and places wherever you go.

- 32 Equipment
- 39 Cities, Buildings and Interiors
- 42 Landscapes
- 44 People
- 47 Composition

Geotagging Your Photos

GPS-capable cameras, smartphones and tracking devices record precise geographic coordinates with your image data. Image management software and Web portals are now using geodata to create intricate maps and huge databases of location-based information, rapidly turning geotags into universal image management tags.

- 50 Overview
- 53 GPS Cameras and Smartphones
- 55 Accessory GPS Receivers
- 58 Loggers
- 59 Displaying and Organizing Geotagged Images

Camera Test

We test four new prosumer DSLRs and stack them up against the Olympus PEN E-PL1 and Sony's innovative Alpha 55. All you need to know about the latest models.

- 64 Interchangeable-lens Camera Test

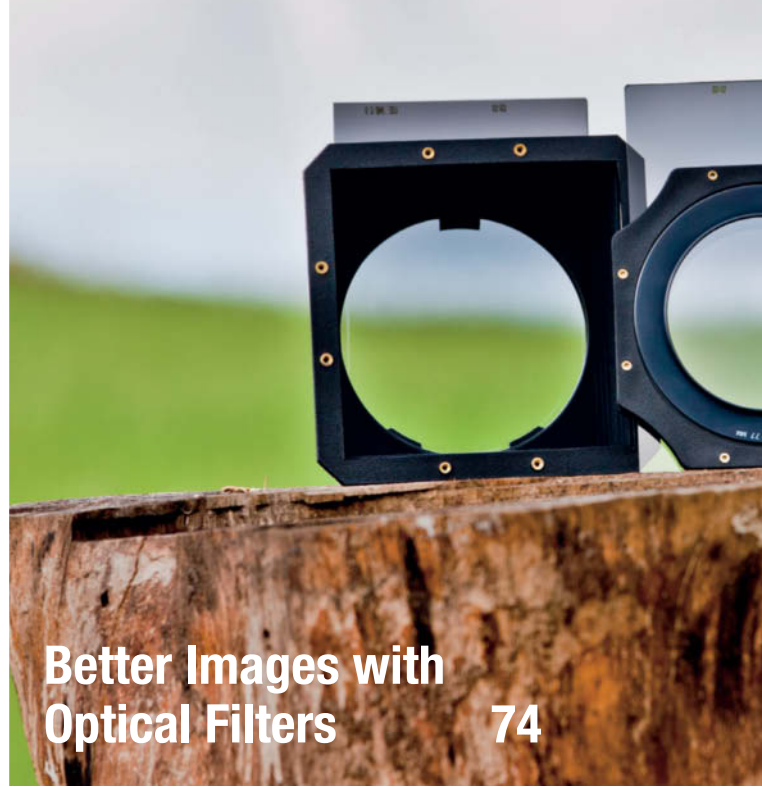
Optical Filters

Why attach a filter to your lens when your image processing program is chock full of digital filters and adjustments? The answer is because some filter effects simply cannot be reproduced digitally. Workshop and buying guide.

- 74 Creating Special Effects using Optical Filters



Camera Test: Mid-range Rivals 64



Better Images with Optical Filters 74

Image Stacking

Simple idea, fantastic images: If your camera can't capture all the data you need to get the effect you want, why not take several different photos of the same subject and merge them into a single super-image? The results are amazing: less noise, more dynamic range and images that look just like the scene you remember.

98 Image Stacking Tricks and Techniques

Elements 9: Should You Update?

The latest release of Adobe's image processing and media management software for advanced amateur and semi-pro photographers once again raises the bar in this segment. We give you the low-down on what's better and where Adobe still has room to improve.

114 Photoshop Elements 9

Digital Terminology Explained

A lot has happened in the world of photography since its invention and the pace of change introduced with digital technology has given rise to a whole new language. This article explains the most important digital photographic terms.

118 A Glossary of Digital Photography

Extreme Subjects

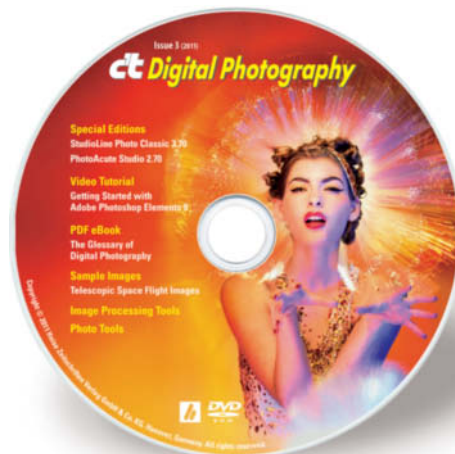
Are you on the lookout for new subjects? We have found two that are worlds apart, but which share the fact that they cannot be seen with the naked eye alone.

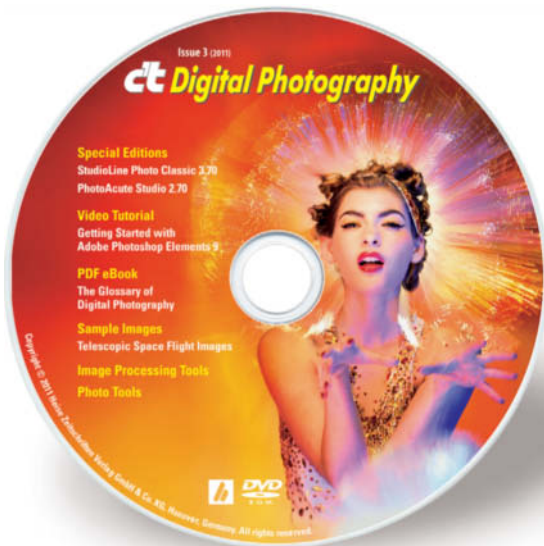
92 Photographing the ISS
128 Bursting Bubbles

Free DVD

Alongside our selection of trial and special version software, this issue's free DVD includes a two-hour video tutorial on Adobe Photoshop Elements 9 and a PDF eBook that explains more than 1,500 of the latest digital photographic concepts and buzzwords. We have also included additional images from space to go with this issue's article on photographing the ISS.

6 DVD Contents
7 DVD Highlights





eBook

The Glossary of Digital Photography

Video Tutorial

Getting Started with
Adobe Photoshop Elements 9

Full Version Software

PhotoAcute Studio 2.70
Special Edition (Windows, Mac)
StudioLine Photo Classic 3.70.21.0
Special Edition (Windows)

Image Processing

Windows

Artweaver Free 1.2
Chromagic 1.0
Gimp 2.6.11
Gimp Portable 2.6.11
GREYC's Magic Image Converter (G'MIC) 1.4.5.2
Helicon Filter 4.93.2
HeliosPaint 1.4.4
ImageMagick 6.6.5-10
ImageMagick 64-bit 6.6.5-10
Liquid Rescale 0.7.1
Liquid Rescale Portable 0.7.1
Luminance HDR 2.0.1
Normalmap 1.2.2
Paint.NET 3.5.6
Plug-In Switch 1.3
PSPI 1.0.7
RegiStax 5.1.9.2
Separate+ 0.5.8
Wavelet decompose 0.1.2
Wavelet denoise 0.2

Mac

Gimp 2.6.11
GREYC's Magic Image Converter (G'MIC) 1.4.5.2
HeliosPaint 1.4.4
Luminance HDR 2.0.1

Linux

GREYC's Magic Image Converter (G'MIC) 1.4.5.2

Photo Tools

Windows

Enblend/Enfuse 4.0
EnfuseGUI 2.1.2
ExifTool 8.40
Foto-Mosaik-Edda 5.7.0
GeoSetter 3.3.60
Geotag 0.071
GPSBabel 1.4.2
Hugin 2010.2.0
Hugin 64-bit 2010.2.0
Image Composite Editor 1.3.5.0
Image Composite Editor 64-bit 1.3.5.0
JetPhoto Studio 4.9.5
Photomapper 0.7
TSR Watermark Image Software 1.9.5.1

Mac

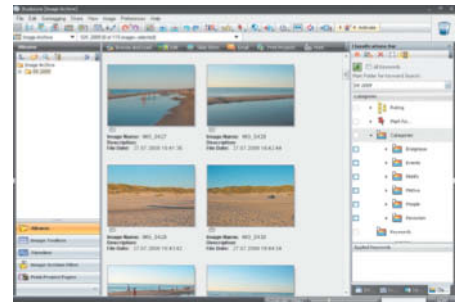
EnfuseGUI 2.1.2
ExifTool 8.40
Geotag 0.071
GPS-Info 2.0
GPSBabel 1.4.2
GPSPhotoLinker 1.6.4
HoudahGPS 4.1.1
Hugin 2010.2.0
JetPhoto Studio 4.9.5
Sofortbild 1.1.1b2

Linux

ExifTool 8.40
Geotag 0.071

Sample Images

Telescope Space Flight Images



StudioLine Photo Classic *Special Edition*

This special c't edition is a practical all-in-one photo processing tool with exclusive geotag support and a special full version discount for c't readers.

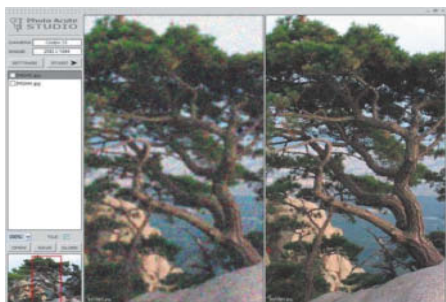
StudioLine Photo Classic unites image processing, storage, image management and presentation functionality in one easy-to-use interface with an introductory wizard to help you get up to speed. The program supports all common image formats and stores results in its own database. This exclusive c't edition of the program supports geotags, and uses the geo-data stored with your images to automatically identify the country, town and street name of each photo's location. You can use location data to sort, filter and search your images.

In order to activate the c't special edition, you require a key that you can obtain either via the link included on this issue's free DVD or directly via the program interface. You need to provide your first and last names and a valid e-mail address to get a key, which is valid until October 7th, 2011.

The c't special edition of the program also includes Timeline view and custom printing features, while the full version also includes additional Gaussian Blur, Unsharp Mask and Selective Soft Focus features. c't readers who upgrade to the StudioLine Classic Plus version using the program's update feature will receive a €19/US\$25 discount and access to additional Web gallery, custom layout and save to external media functionality. (keh)

DVD Highlights

The DVD's many highlights include special versions of *StudioLine Photo Classic* and *PhotoAcute Studio*, as well as a video tutorial on *Getting Started With Photoshop Elements 9* and the eBook *The Glossary of Digital Photography*



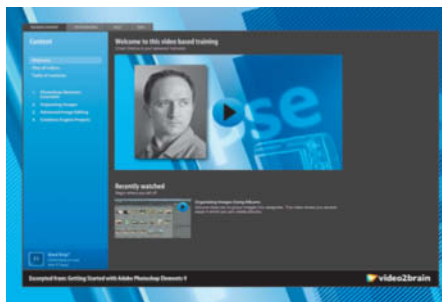
PhotoAcute Studio 2.70 Special Edition

PhotoAcute Studio is an easy-to-use tool for producing reduced-noise, ultra-high-resolution, or HDR images from sequences of source image files.

PhotoAcute uses the data stored in a sequence of source images to produce a single reduced-noise or ultra-high-resolution image. The program has a user-friendly interface, reads RAW files, and is capable of saving to JPEG, 16-bit TIFF, PNG and DNG formats. It also includes functionality for removing unwanted moving objects, focus stacking (i.e., merging multiple images with differing focus settings to a single image with increased depth of field) and HDR image production.

PhotoAcute has its own image alignment feature, which is capable of saving aligned images individually for processing in other programs. Corrections to image geometry can be performed using user-selected camera/lens profiles. The number of lens profiles available varies from camera to camera. If your particular lens is not profiled, it is possible to use the profile from a lens similar to the one you are using, but the resulting lens correction and ultra-high-resolution stacking results will be less accurate. The program also includes a feature for removing color fringing.

The manufacturer is offering a 15 percent discount on all full version licenses for the latest version of the product purchased before June 1st 2011. A license includes updates for a full 12-month period. (R. Altmann/keh)

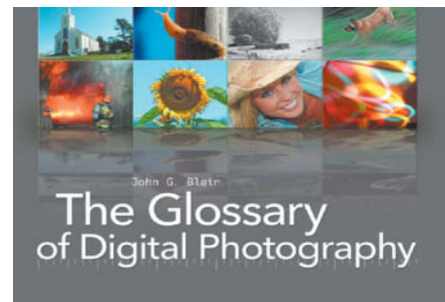


Getting Started With Photoshop Elements 9

This two-hour video tutorial introduces the basics of working with Photoshop Elements 9, as well as advanced techniques for experienced hobbyists.

Photoshop Elements 9 is the latest version of Adobe's image processing and media management package for advanced amateur users. Version 9 includes a number of important new features but remains simple and intuitive to use.

The tutorial is divided into four sections. Section 1 covers the basics of the program's interface, including the Welcome Screen, working with the Organize and Edit workspaces, image data backup, and an overview of the available tools and their uses. Section 2 addresses the program's media management functionality, and explains the principles of image organization using albums and keywords. Section 3 goes into detail on advanced image processing techniques, including the Layers functionality that is essential to many complex imaging projects, photo collage techniques, and the program's unique Photomerge tool. The five Photomerge sub-tools include the Exposure Guided Edit for merging multiple, differently-exposed images into a single, correctly exposed photo and the Scene Cleaner Guided Edit, which you can use to combine elements from several photos in a single image. The final workshop section explains how to create slideshows to showcase and share your images, and how to create greeting cards using the new skills you have acquired. (keh)



The Glossary of Digital Photography

This PDF glossary strives to help those involved in this cutting-edge industry to understand the constantly-evolving language that it generates.

One hundred and eighty years of photography, 20 years of Photoshop, 10 years of digital cameras – digital photography is a relatively new discipline that is still undergoing rapid change that, thanks to new developments in semiconductors, is unlikely to slow down any time soon. New cameras, accessories, techniques, and applications are constantly being introduced, making it necessary to create new words to describe them. The result is a complex web of interwoven technical and artistic terms that even some veteran photographers have trouble understanding.

This extensive PDF glossary is designed to help you keep pace with all the latest developments, and includes definitions of more than 1,500 digital photographic terms, plenty of illustrations, and a comprehensive set of cross-references.

The book has been extensively researched to include all terms in current use and to provide their most up-to-date meanings. It is designed to be equally useful to students, amateur or professional photographers, designers, image-makers and anyone who is involved in pre-press or publishing. The original print version of the book was published in 2007 by Rocky Nook, and the latest version can be found at: www.rockynook.com/books/22.html. (keh)

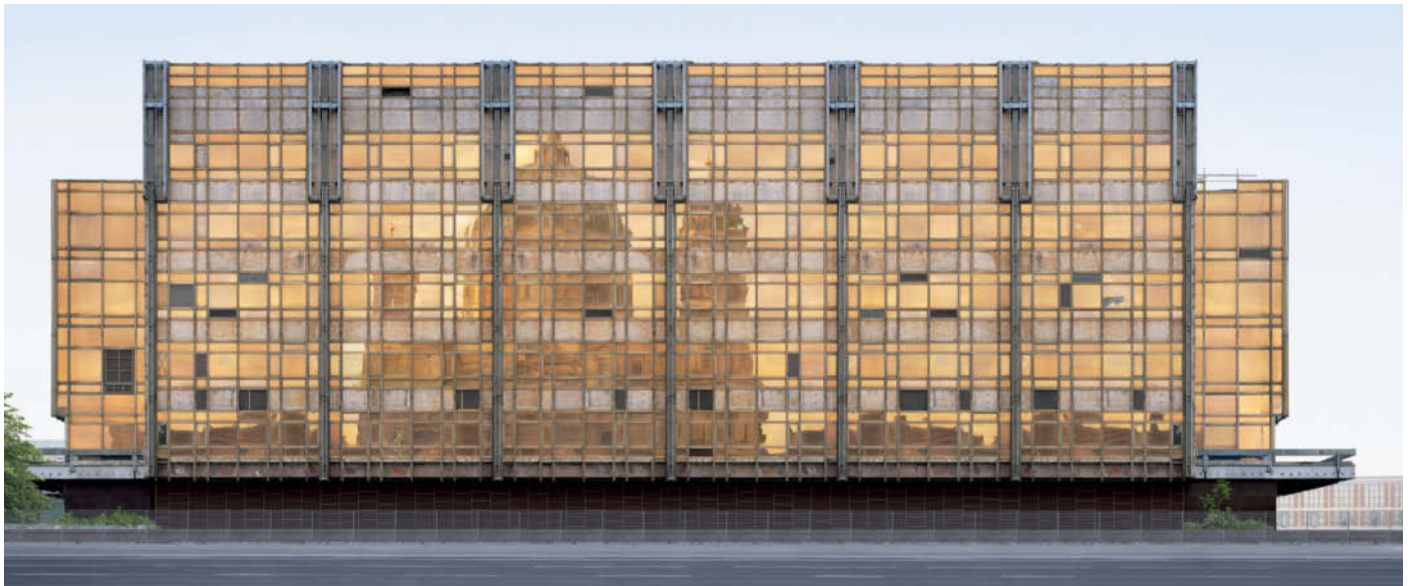


Portfolio

Lukas Roth



Aquarium (2007): The shark at the top appears to be swimming out of the top of the photo, creating a physical link with the viewer. The viewer becomes immersed in the image, making it impossible to view the aquarium from outside.



Palast (2003): The idea for this photo came up spontaneously during a trip to Berlin in which Lukas Roth photographed right through the night until dawn. The individual photographs were published in 1993, before there was any hint of plans to demolish the Palace of the Republic, a landmark of the former East Germany. It is not actually possible to capture the reflection of the Berlin Cathedral from this perspective.

Born in Regensburg, Germany, in 1965, Lukas Roth specialized in architectural photography at the École Nationale de la Photographie in Arles, France. After returning to his own country, he launched into self-employment as an architectural photographer in 1991 and, since then, contract work for architectural practices and other companies have formed the basis of his professional work. Since 2002, he has also been developing the artistic side of his photography. His aim is always to capture his personal impression of a place and its atmosphere rather than a strict photographic representation. The German Photographic Association (DGPh) Otto Steinert Prize in 2004 and numerous exhibitions prove that the distinctive aesthetics of his art strike a chord with viewers. In 2008, he was inducted into the Deutsche Fotografische Akademie (DfA) and the German Photographic Association. Roth lives and works in Cologne.

The Photographic Art of Lukas Roth

Viewers recognize the view from the Pont du Gard or the shot of the Palace of the Republic immediately. The photos seem to match their

memories, but gradually people become aware that something is not quite right. Is it really possible to see the Berlin Cathedral reflected in the windows of the Palace? No!

Not a single one of the buildings and landscapes shown here can be photographed as they appear in Roth's images, which he compiles from numerous source photos on his computer. The key to his art is the conviction that the optical impression of a place comprises many images: walking through a building, we experience the space in three dimensions, from many vantage points and from different positions. In his images, Roth works backward from these memories to interpret the location or building.

Using a large format analog camera, he takes thousands of photos of the subject from different points of view, then selects several hundred to work on in *Photoshop*. The result is massive files that can be as large as 40 GB. It takes three months to craft one of these exceptionally detailed works. He creates the images and sets up the merging process himself, and an assistant helps him with the actual image processing.

Lukas Roth's art inhabits the space between photography and perception or memory. He interprets places for us instead of just

showing them to us. Something new and illusory is created that corresponds to his personal impression of the place or building. It is neither a photograph nor a likeness – even when merely trying to categorize these works, we find ourselves testing new boundaries. (jr)

Pont du Gard (2005): Lukas Roth knows this spot on the Pont du Gard well thanks to his years at university in Arles. In fact, there is no way to get a good shot from this perspective. By combining many individual shots into a single artificial image, he shows us a view from the bridge that would simply not be visible if we went there ourselves.





Bibliothek (2005): This library at a law firm in Cologne is visible to passers-by. Roth chose a slightly modified Frankfurt skyline as the basis for the look of his image. There is something strange about the lighting, and the shadows under the bookshelves don't quite match with the light produced by the ceiling lamps.

Gletscher I (2008): Three trips to the Rhône Glacier in Switzerland, at different times of the year, were required to obtain sufficient source material for this image. The layered landscape is disconcerting because areas that are further away look much larger than they are in reality.



This dead forest is cut off, stranded in the middle of a motorway interchange. The cut timber cannot be carted away but is simply left to rot. Unusually for Roth, this image was created using just three source photos.







Tropen (2007): The artificial "Tropical Islands" tourist attraction in Berlin is a perfect subject for Lukas Roth's surreal approach to photography. He originally wanted to climb the roof beams and shoot from there, but ended up having to shoot from a hot air balloon instead. **c't**

Thomas Saur

Studio

Lighting

Lighting has a strong influence on the emotional effect of a photographic portrait. Badly composed lighting can have an unflattering effect and can even make a subject look ruthless or evil. On the other hand, well-thought-out lighting can make a portrait subject appear interesting and attractive. A studio photographer needs to have a good grasp of the effects of different types of light and should be well versed in the use of the tools available to shape it.





Indirect Light using a White Umbrella

An umbrella is an extremely portable and versatile piece of lighting equipment. Used as an indirect reflector, a white umbrella produces soft, diffuse light.

Studio Flash

Most photo studios use professional flash equipment to produce portrait lighting effects. A basic flash setup consists of three or four flash heads and a selection of attachments for shaping the light that they produce. A set of reflectors and absorbers with appropriate stands, tripods and clips is also essential. A high-quality flash head allows you to independently adjust the brightness of the modeling light and flash output and offers a wide range of finely adjustable settings.

Types of Studio Light

A “naked” studio light behaves much like a spotlight and produces hard shadows. It is only when you begin using special tools to manipulate light that things start to look in-



This flash head has two independent adjusters for setting the brightness of the modeling light and flash output

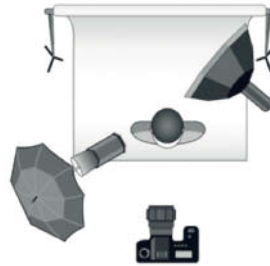
teresting. Generally, portraits look better if they are lit using “soft” light that is either reflected or diffused. Many portrait photographers use either translucent umbrellas or softboxes to light their subjects. Silver or white reflective umbrellas are usually only used as subsidiary reflectors in portrait situations. Other light shapers include spot attachments and snoots.

The Basic Components of a Lighting Setup

A basic studio lighting setup consists of three or four flash heads that act as the **main light** (i.e., the light that defines the overall look of an image), a **background light** and one or two additional **effect lights**.

Background Light

The color of background light is variable, and is usually created using heat-resistant colored



Silvered Umbrella

Silvered umbrellas reflect light more intensely than white umbrellas and bundle light more efficiently. The light they produce is slightly “harder” too, giving more emphasis to fine textures.

gels. It is deceptively simple to use colored light to transform everyday gray card into a colored background. Background light can be solid or graduated and is nearly always adjusted in direct proportion to the brightness of the main light. If the brightness of a graduated background diminishes in the opposite direction to the emphasis of the main light, the subject will appear better defined against the background. Using a circle of diffused light in the background can give a portrait subject an additional “aura”.

Fill lights are used to reduce or soften the shadows produced by a main light or to selectively brighten subject details. Care is required when using fill lights: if your fill light throws a shadow of its own it can cause an unwanted “pincer” effect. Reflectors are often simpler to use, as they don’t actually produce shadows.

Effect Lights

Effect lights are used to accentuate specific aspects of a subject or a set. They can be used to selectively light parts of a subject’s face and are often highly focusable. “Barn doors” attachments and snoots are a cheaper, but less flexible way of focusing light. One particularly popular lighting effect is a “hair light”, which is usually positioned behind a portrait subject’s head to produce highlights in and around her hair. Hair light effects used to be popular among Hollywood movie directors and served to visually separate the person being filmed from the background.

Lighting Distance

In addition to the quality and “hardness” of a photo light, its distance from the subject has a significant effect on the overall look of the resulting image. The closer the subject is to

the main light, the more lustrous and three-dimensional she will look. If you move your light source away from the subject, the results will have less contrast and a more homogenous, but less punchy overall look.

Background Distance

If your subject is located close to the background, the main light will most likely illuminate the background too, producing visible shadows of the subject. This effect is easily avoided by ensuring that there is sufficient distance between your subject and the background. This also helps you to separately control the effects your main and background lights have in the final image. The following sections illustrate various light shaping tools and the effects they have on portraits shot using different types of main light.



Striplight

A striplight is basically an elongated softbox that is specifically designed for use in portrait and fashion photography. A striplight has proportions of 1:3 (or longer), while conventional softboxes are usually square. We used an indirect flash head aimed backward in the striplight in our example, which produced a particularly diffuse lighting effect. You can use striplights to light standing subjects evenly without having to bathe the entire studio in diffused light, as you would have to if using a square softbox.



Softbox

Softboxes have one or two built-in diffusers that produce soft light, soft shadows and distinct color differentiation. Smaller softboxes, measuring 24 inches or less, are not capable of illuminating a person from head to toe, but to produce graduated lighting effects which you can use deliberately to emphasize a subject's face. Here too, the closer you place your softbox to your subject, the more intense the results will look.





Direct Lighting using a White Umbrella

If you use direct flash aimed through a white umbrella, the light is diffused and produces a pleasant effect similar to that produced by a softbox.





Simple Spot with Barn Doors

Movable barn doors allow you to produce shaped, directional light that can be set up to have symmetrical or asymmetrical effects



Snoot with Honeycomb

A snoot narrows the beam of light to produce extremely selective lighting effects





Hair Light

A popular classic lighting effect from a bygone Hollywood era, hair lights were originally used to create a feeling of visual separation between the person being filmed and the background. They also add glamour to a shot. In studio situations, we usually use a narrow beam from a simple spot with barn doors as a hair light. Hair lights are directed at the back of the subject's head from behind. In order to avoid producing unwanted highlights, you should make sure that a hair light doesn't point directly into the camera's lens and that it isn't visible in the final crop.



Angled Light

The angle a light is placed at has a significant effect on the distribution of light and shade in a portrait. Here, the light was placed at precisely 45 degrees to the subject's face and produced a dynamic, but slightly gloomy effect. This type of effect is great for emphasizing a subject's character, but produces too much shadow for a successful beauty shot. In a glamour situation, it is a good idea to use a different lighting angle or make sure you use sufficient fill lights to brighten the shadows.



Direct Frontal Light

Here, we used the same light as in the previous example, but shifted the lamp to the right to produce a more direct effect. In this case, our model's face is more brightly lit and contains fewer shadows. It's worth experimenting with subtle differences in lighting angle.

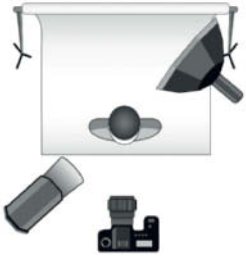






Honeycomb Diffuser

Honeycomb diffusers are made of metal and are designed to minimize diffusion while producing directional light. They also increase image detail.



Simple Reflector

This is the most basic of all standard light shaping tools – a short metal tube that directs “hard” light directly at the subject. At close range, a simple reflector can be used to produce well-defined, high-contrast portraits. Be careful to control the intensity of the light you use, as light-colored details can quickly appear burned out in this type of light. However, depending on the style of the shoot, some photographers use intense flash to deliberately wash out surface detail during portrait sessions.





Without Reflectors

In this photo, we lit our model from above, producing unflattering shadows under her nose, eyes and chin.



With a Reflector from Below

Here, a reflector eliminates unwanted shadows, while the reflection from the surface of the white card we used produces an interesting glint in the model's eyes.



Reflectors and Absorbers

Reflectors, made of white card, plastic or fabric, are generally used to increase detail in studio portraits by softening the shadows produced by the main light. Silver reflectors reflect more light but produce a harder light than white reflectors. Gold reflectors produce warmer tones and are often used to brighten faces from below, or to improve skin tones

and eliminate nose and eye shadows during beauty shoots. Facial reflectors can also be used to produce a glint in a model's eyes. When shooting portraits, it is important to concentrate on the shadows in your photo as well as on the lighting effects. You can use absorbers, too, to regulate facial shadows.

The human eye instinctively compensates for lighting discrepancies, making it difficult to accurately judge the look of an image on

set. The effects of an absorber are, however, extremely obvious in a finished photo. Absorbers are usually made of matt black card or fabric. Make sure that you have a selection of reflectors and absorbers mounted on stands or tripods before you start your shoot. Cheap lamp stands and clips from a hobby store are perfectly adequate for the purpose, and flexible, gooseneck microphone stands make great reflector mounts, too.



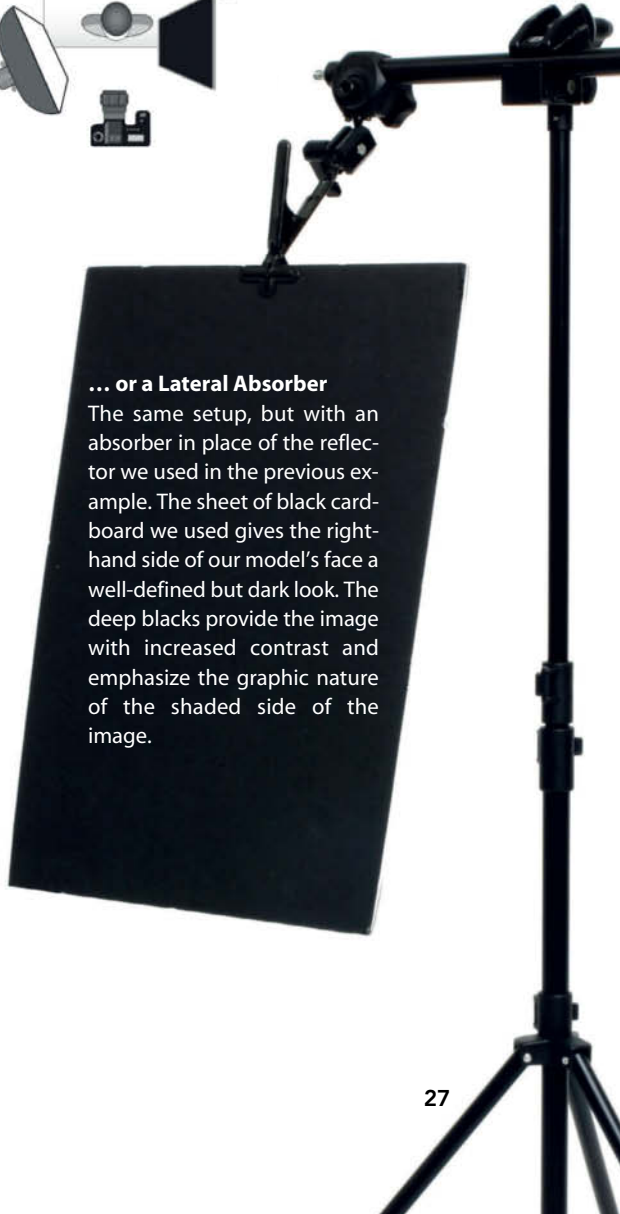
Using a Lateral Reflector ...

In this example we used a softbox to the left of our model as our main light and a sheet of white Styrofoam on the right to soften the shadows and improve detail and contrast



... or a Lateral Absorber

The same setup, but with an absorber in place of the reflector we used in the previous example. The sheet of black cardboard we used gives the right-hand side of our model's face a well-defined but dark look. The deep blacks provide the image with increased contrast and emphasize the graphic nature of the shaded side of the image.



DIY Light Shapers

White card and Styrofoam are just as effective as industrially manufactured reflectors. Alternatively, you can build a simple metallic reflector out of cardboard and a rescue blanket snaffled from a first-aid kit.

Quick as a Flash!

A photographer has little influence on the shutter speeds that can be used with flash. Even if your camera has a flash sync setting of 1/125 or 1/250 of a second, the photo itself is captured during the flash, which only lasts for 1/1000 or 1/2000 of a second. The advantage of short flash times is that you can shoot handheld without the risk of camera shake spoiling your results. In our sample photos, the model's hair appears perfectly sharp in spite of the quite violent movements she was making during the shoot.








Shooting Using a Modeling Light and a Wide Aperture

The combination of motion blur and shallow depth of field makes these images particularly appealing.

Portraying Movement

The current crop of DSLRs is capable of producing high-quality results at high ISO speeds. You can adjust white balance in the camera to compensate for the warmer temperature of a studio modeling light, making it possible to work without flash in a controlled studio situation. While you are limited by the duration of the flash itself when shooting with flash, you have a free choice of shutter speeds when working with just a modeling light, making it possible to use motion blur effects creatively and shoot at the wide apertures that using flash normally precludes. There are no limits to the combinations of apertures and shutter speeds you can experiment with. (ae) 



Reinhard Eisele

Travel Photography

Broadening your horizons, taking you from the familiar to the unfamiliar, travel photography is not just about capturing memories, but also about intensifying the travel experience through contact with new people and places. In this article, photographer and author Reinhard Eisele shares some tips on preparing for travel, taking successful travel photos and choosing the right subject.



Contents

Equipment	32
Cities, Buildings and Interiors	39
Landscapes	42
People	44
Composition	47

Camera gear limits your freedom of movement, makes your luggage heavier and attracts thieves like magic. Most famous landmarks have already been photographed a million times and book shops are full of photo books of all shapes and sizes. So why take travel photos at all?

The answer is provided by those who see the journey itself as the destination. The people, towns and landscapes that you pass on your way make the difference. The real travel experience lies in seeing the world around you, and the challenge lies in recording your own subjective view of the world in a way that is accessible to others.

Photographers who manage to communicate their own fascination and to identify the essence of the scene they are portraying take exceptional photos. The more personal the statement you are making, the more powerful your images will be.

If you take the trouble to consider lighting and composition, and if you wait for the right moment instead of just “snapping away”, you will begin to observe your surroundings differently and to experience your travels on a higher level. Photos are created in the photographer’s mind, making pressing the shutter button to take the photo a purely technical act.

Experienced photographers sometimes decide on an overriding theme – including the general message they want to convey – before they set out. Are dramatic landscapes your priority, or do you want to portray the multi-faceted nature of the people who populate them? Or are flora and fauna the main subject? If you don’t have a clear idea of your intentions before you start, you risk becoming a generalist snapshot photographer.

Research

After agreeing to shoot for a major photo book of the United States I began my preparation for the trip by considering “my” view of the USA, including which aspects were most important to me and which I could safely leave out. I started by looking at other photo books to get an idea of the different ways a

country like the US can be portrayed. Articles in magazines like National Geographic and Outdoor Photographer helped me to choose the best time of year to travel. If you want to photograph the contrast between the green bloom of spring and the craggy cliffs of the Yosemite National Park, you need to be there during May to be fairly sure of getting the pictures you want. The weather, is, of course, not always reliable, and you will need to check the forecasts before you travel to be sure of catching the right moment.

The famous "Indian summer" in north-eastern New England and Colorado also produces extreme reactions, with the local newspapers and radio stations reporting the coloring of the leaves for a period of several weeks leading up to the high point of the season, which usually lasts just a few days. The exact timing of the seasons changes every year and you cannot, of course, fix a date in your diary in advance.

If you are photographing towns or cities, you can use maps and city guides to help you prepare the "shooting script" for your trip. Make a note of the times and dates of local markets, as these provide an ideal opportunity to photograph local color while remaining largely unobserved.

Once you have decided on your destination, your schedule, and the main themes of your shoot, you can begin to assemble your

gear and get into training for your trip. You will only be able to capture critical moments if operating your gear has become second nature.

The right choice of equipment depends very much on how you will be moving around once you reach your destination. If you are planning to use a private vehicle and are fairly sure you won't have to move more than a few hundred yards away from it, you can take all of your longest lenses and several camera bodies along in a heavy-duty case. If, however, you are going to be travelling by airplane or bus, it is a good idea to reduce the amount of gear you plan to take with you. Experience has shown that too much equipment can be more harmful to a successful shoot than the lack of an accessory or two.

Digital Single Lens Reflex Cameras

DSLRs that allow you a useful degree of control over the photographic process start at around US\$500. Consider the following points when choosing a camera:

Resolution and sensor format: The ideal resolution depends on how you intend to publish your images. If they are destined for printing in calendars or magazines (i.e., for offset printing) use a camera with a full-frame sensor and resolution of at least 12 megapixels. This al-

The rainy season is often a tourist's nightmare and a photographer's dream. This image shows a longhouse settlement in Borneo during the monsoon.





lows you to make high-quality double-page spread prints. Resolutions of 17 megapixels and more allow you to print large posters without sacrificing image definition. Sensor formats also play a significant role in the amount of image noise a camera produces. Full-frame sensors – measuring 24×36 mm – are more expensive but deliver the best results. Smaller APS-C sensors (e.g. 22.2×14.8 mm) have lower resolution and tend to produce more image noise at ISO speeds of 400 and more. A full-frame sensor also allows you to frame your images more generously and to crop them later without losing image quality.

Eight-megapixel sensors used together with low to moderate ISO values are sufficient for producing high-quality prints in sizes up to about 16×24 inches, provided that your print service uses high-quality machines. Lower resolutions are usually adequate if you want to project your images electronically.

Camera build quality: Make sure your camera is tough enough to stand up to the knocks and scrapes – and even falls – that inevitably occur at markets, festivals and bazaars. The best (but also most expensive) cameras are made of magnesium alloy.

Water and dust resistance: Some high-end cameras are also dust and water resistant, which is important if you are shooting in tropical regions or at sea, where salt water espe-

cially can spell disaster for cameras that aren't sufficiently protected against the elements. In the desert and on safari, even the smallest opening in the fasteners on your camera bag can lead to serious sand and dust problems.

Display: The larger your camera's display, the easier it will be to frame and assess your images under difficult lighting conditions. Live View functionality is also sometimes useful – for example, if you need to hold your camera in a low position – but is not essential.

Aperture and shutter priority exposure:

It is always preferable to be able to choose which exposure mode you use. Shutter priority helps when you are shooting fast-moving subjects, while aperture priority is more useful for landscape or portrait shots. I don't recommend using programmed auto mode, as this leaves all the thinking to the camera and doesn't help you to refine your technique.

Exposure metering: A camera with multiple metering modes, including spot, center-weighted and matrix, is ideal for travel photography.

Image stabilizer: Built-in image stabilization functionality is useful, but not absolutely necessary. To shoot at lower shutter speeds using short lenses, all you need is a steady hand. For focal lengths of 180 mm and above, I recommend using stabilized lenses.

Festivals and markets are photographers' eldorado. The image here was taken at the annual November camel market at Pushkar in the Rajasthan desert in India. Sunrise and sunset provide the most spectacular photo opportunities.

The rainy season is a great time for finding different moods in your subjects. This rice farmer's hat acts as his umbrella while he walks home in the warm monsoon rain in Bali.



Depth-of-field preview: This is an extremely useful function, especially when you are photographing landscapes or architectural subjects.

Sensor auto-clean: The more often you swap lenses, the greater the risk of dust particles settling on your camera's sensor and spoiling your images. Automatic sensor cleaning functionality is a great help and is built into most mid-range and high-end cameras.

Shooting rate: The number of frames per second (fps) your camera can shoot varies according to the image format and quality settings you use. RAW files take longer to write to memory than JPEGs and make shooting slower. A high shooting rate can be helpful in some documentary situations, but is not one of my personal priorities for travel photography.

Geotagging: Geodata integrated in your files' Exif data saves a lot of time spent making notes and is also useful if you want to display your images on Google Earth or Flickr. Check the compatibility of your hardware and software before you start your shoot, as not all RAW formats support geodata and some cameras can only save it in separate JPEG files. The geotagging market is developing rapidly, and camera manufacturers and third-party companies (such as GeoSetter) are constantly expanding their range of offerings.

Take a Second Camera

EVERY electronic camera can fail. A second camera body is an essential part of every travel photographer's kit, especially if you are travelling in extreme climates.

In analog times, a simple, mechanical camera was an ideal backup, with the film itself being the most important link in the photographic chain. A specific film used with particular lenses produced reliable results. Nowadays, the look and feel of the final image depend largely on the size and resolution of the camera's image sensor, so it makes little sense to use an 8-megapixel APS-C camera as backup for your 17-megapixel full-frame main camera.

Fixed Focal Lengths or Zooms?

A few years ago, photographers had to decide whether they were prepared to accept lower image quality as the downside of using variable focal length zoom lenses. Today, zoom image quality is often just as good as that produced by fixed focal length lenses. I use a full-frame Canon EOS-1Ds Mark II together with the following lenses:

- A 17–40 mm wide-angle zoom
- A 40–70 mm standard zoom
- A 70–200 mm telephoto zoom
- Two teleconverters (1.4× and 2×)

I use a teleconverter with my relatively bright telephoto zoom instead of carrying a heavy super-telephoto. Teleconverters only start to cause problems if you use them with lenses that have relatively small maximum apertures. However, it is also possible to use just one lens. Perry Kretz, who shoots worldwide reportage for Stern magazine swears by his f3.5–6.5 18–200mm zoom, which he uses with an APS-C camera.

Saving images on the road

Whether you want to re-use some memory card capacity or make data backups, it is essential to copy your images regularly while you are out and about. A notebook computer is the best tool for saving, viewing and processing images on the road, but is unwieldy compared with a mobile hard disk with a built-in display.

Ideally, I would send my image files home directly from my location. Direct transfer protects you against loss through theft or damage, but the large amounts of data involved (2.5 GB for 500 JPEGs) make it virtually impossible to send data via public e-mail or from Internet cafés.

Accessories

Filters: I always take UV and polarizing filters along. A UV filter not only protects the front element of my lenses from dust, spray and sand, but also reduces unwanted blue casts in brightly lit subjects such as snowscapes. A polarizer increases subject definition against blue skies and reduces differences in contrast caused by bright skies or haze.

A graduated neutral density filter can help to equalize contrast above and below the horizon, while a sunshade always helps to avoid unwanted reflections caused by stray light. Star, color, prism, or other effect filters are not usually part of a travel photographer's kit.

Remote shutter release: A remote release guarantees shake-free shooting and is essential for preserving sharpness when you are shooting landscapes with great depth of field. A self-timer does a similar job, but makes it more difficult to time the moment of exposure precisely.

Tripod: If you are using a remote release, you will need a tripod too. No serious travel photographer sets out without a tripod, which is an essential tool, not only for night shots with long shutter speeds but also for landscape or architectural shots that require you to shoot at shutter speeds as low as 1/4 second in order to achieve appropriate depth of field, even in daylight.

Having your camera fixed to a tripod also helps you to concentrate on your framing and compositional details – like level horizons – that are easy to overlook if you are shooting “from the hip”.

Taking your time to get a feel for your chosen subject often makes the difference between an image that has obviously been just “snapped” and one that has been carefully and attentively composed and photographed.

Flash: A travel photographer should always carry an accessory flash for adding subtle highlights to a shot. An extension cord will help you to produce additional lateral light. Practice with test subjects at home to make sure you know exactly how to dose your flash when you are in the field. I recommend a guide number of at least 30 for an accessory flash.

Camera bag: Make sure your bag is sturdy enough to carry the weight of your complete kit and to take the knocks that travel inevitably dishes out. A travel photo bag has to be waterproof or have a builtin rain cover.

Additionally, make sure that your bag is comfortable to carry for long periods when it is full. There are a large number of photographer's backpacks available that make long days out and about in a city or trekking in the hills with heavy gear much easier.

Batteries

Motor-driven, autofocus cameras require a lot of power, and it is not always easy to find an outlet for charging your batteries when you are touring. Always carry at least two sets of fully-charged batteries. A 12/230 volt transformer allows you to charge your camera gear while you are driving and doesn't usually cost more than about US\$30.

Many camera batteries perform less well in the cold. If your batteries are nearly drained and you don't have a second set of batteries with you, switching off autofocus and switching off your camera between shots saves precious power.

And Not Forgetting ...

Remember to pack a reserve lens cap, a mini screwdriver for making running repairs to your gear and a pocket knife for removing unwanted twigs and leaves from your composition. Always take a notebook and pen for noting place names or other image details, and pack a flashlight or a headlamp for finding your way in the dark. I always take a compass along too. There is an enormous range of camera cleaning tools available, but I use just a blower brush and a soft leather cloth.

White Sands in New Mexico, USA is the largest gypsum desert in the world – a fantastic area that offers endless landscape photo opportunities



Cities, Buildings and Interiors

Their images fill countless coffee table books, postcards show them from every possible angle: the Eiffel Tower, the Taj Mahal – as if it hadn't been photographed millions of times already, the almost obligatory view of New York, or the umpteenth shot of San Francisco's Golden Gate Bridge. So how do we find a fresh take on photographing cities?

It can be a hard slog, but extremely effective: the best way to get to know a city is usually on foot. This is true not just in San Francisco, which is famous as a "walking opportunity", but in urban environments the world over. The many hours and days I have spent walking through New York, Chicago, Calcutta, London and Prague have yielded shots far beyond what you find in the average travel brochure. Cover longer distances in a taxi or some other form of public transport, by all means, but the best way to discover the character of a city is by walking. You will be rewarded with fantastic photo opportunities, especially when other tourists are sleeping.

Shooting at Popular Tourist Attractions

The first time I went to Prague, people warned me that it was hopelessly crowded.

They said Charles Bridge, one of the city's most famous landmarks, would be so thick with tourists that I would hardly be able to move, let alone take photos.

On my return, everyone was amazed by my pictures of the bridge with not a person in sight, as if I had somehow stepped back in time to how we imagine it was in Mozart's day.

Digital trickery? Not at all – simply the right time of day. Most visitors appreciate not having to rush off to work and like to make the most of their hotel's breakfast buffet until 10 a.m. But the sun comes up between 5 and 6, depending on the season, and at that hour, Charles Bridge in Prague, like St. Mark's Square in Venice and all the famous sights in Rome, is deserted. As well as producing a great photo, visiting the bridge in the early morning was a fantastic personal experience.

If you want to take photos at popular spots during the day with something other

than crowds of people in the foreground, it can be helpful to shoot from an elevated vantage point. On Charles Bridge, for example, you can perch on the balustrade – if you're feeling energetic and have a head for heights. Or look around a bit and you may find that there's construction or renovation in progress that provides some handy scaffolding for you to perch on.

If you're taking shots of a city from an exciting vantage point for the first time, you need to give yourself plenty of time, lest you forget your telephoto lens as you concentrate on panorama and general views. However, depending on the situation, long focal lengths can create just as fascinating photos as wide-angle lenses.

A Matter of Timing

Make sure you have a good map and a compass, which you can use to figure out which



The only way to photograph popular places without crowds of people around is at unusual times of the day. Getting up early is a small price to pay for exceptional photos like this one of Charles Bridge in Prague.



Tall buildings and viewing platforms create some fascinating opportunities for photographers. This view of the centre of old Havana was taken from the roof of a hotel using a 180mm telephoto lens.

way a building is oriented and get a rough idea of whether it will look best in morning, afternoon or perhaps evening light.

It is important not to have the light falling on the object directly from the front, as diagonal lighting is the only way to reveal structures and contrasts that make the architectural features come alive. The earlier or later the hour, the warmer the light and the colors it will produce. In the narrow streets between skyscrapers in New York or Chicago, on the

other hand, midday may be the only time certain streets or open spaces catch enough sun to be photographed at all.

Concentrate on brightness and contrast within the frame. The difference between the light and shaded areas can be so extreme that it becomes almost impossible to find a happy medium and your photo will turn out under- or overexposed. You'll need to take several photos using different exposure values to find out what works best.

Evening and Night Photography

Getting the lighting right for evening shots is the ultimate challenge. Often the only way to get a good result is to try a variety of light-

ing choices. Whatever the case, avoid having bright light in the centre of the frame, as this will produce a false meter reading. Because it allows you to check your results immediately after shooting, a digital camera opens up far more opportunities than photographing with film, which often made shooting in low light situations feel like flying blind.

Interiors

Travelling photographers often find themselves inside buildings they would really like to photograph, but such opportunities are fraught with difficulty.

For a start, there is the frequently encountered ban on photography. While there is usually a reason for the rule, it is sometimes imposed simply to protect sales of the slides and photos that are already available. In museums, the main reason photography is banned is to ensure that copyright in the works on display is respected or to prevent light from flash photography damaging the exhibits. In cultures where photography is banned in temples, mosques and other important buildings for religious reasons, this should always be respected.

Sometimes, officials do not allow photographers to use a tripod to photograph buildings or interiors. This is usually to prevent the photos being used commercially, which requires a permit. Apparently a tripod is the mark of a professional photographer. Remember that the owner, whether this is a private individual, a church, the municipal authority or a business, has the right to determine what may and may not take place on the premises. The only way around this problem is to state your intentions in advance and, where necessary, to obtain a permit.

Even if photography is not prohibited, there may be other hurdles to overcome. In most cases, the available light indoors is much darker than the light we are used to using in outdoor situations, and the range of shutter speeds we can use starts at around 1/30 second. There are only two options in this type of situation: either use the available light or use a flash. The latter solution is unavoidable for many interior shots, especially when there is significant contrast between the bright light from outside and the dark interior. Even if the room does not seem dark to us, there will be several stops difference between the inside and outside light levels so that, with normal lighting, either the outside will appear overexposed or the inside will appear underexposed.

A TTL flash – which is controlled directly by the amount of light entering the lens – evens out these contrasts. You meter the lightest and darkest parts of your scene and



It was quite dark inside this old farmhouse despite the bright sunlight coming through the windows. I used an exposure time of one second and diffused flash with flash power reduced by 1½ stops.

illuminate the dark parts with indirect flash. Since interiors are often photographed using wide-angle lenses, your flash should be equipped with a wide-angle reflector and perhaps a diffuser as well. If the room is still too dark, the only way out is to use flash at full power.

Another way of dealing with difficult light conditions is to increase the ISO value, but bear in mind that, depending on the camera model you are using, image noise can be a problem at ISO values of 400 and above. It's a good idea to take a series of test shots before your trip, perhaps in your own home, so that you get a sense of how far you can go in terms of ISO settings before you start to reduce the quality of your images.

Flash without Fuss

You won't usually have a second tripod available for your flash unit when you're on the road, so here's a great trick you can use: mount your camera on a tripod, frame your shot and – holding the flash in your hand – use the self-timer or a remote release to move as far to the side as you can. Just make sure you practice this a few times before you set off! Your own home or a local church makes a good training ground.

Industrial photographers working in huge machine rooms use an interesting

technique to light the large spaces involved. The photographer mounts the camera on a tripod, selects the lowest possible ISO value in order to get a long exposure, sets up the shot and opens the shutter using the B ("Bulb") setting. The photographer then moves through the room, firing the flash several times. Thanks to the long exposure time, the photographer remains invisible in the photo, as long as he or she does not stay too long in one place and is not wearing white.

Converging Lines

The only way to photograph tall buildings so that they look straight is to put sufficient distance between yourself and the building. The closer you get, the greater the angle between the camera on the ground and the top of the building, so the only way to photograph the entire building is to tilt the camera upward – and voilà, the vertical lines go crazy.

Converging lines can also be effectively used to convey a sense of the height in a building; think of the skyscrapers in big cities, for example. Here, the key is to get as close as possible and tilt the camera enough. This can even be taken as far using a "frog's-eye" perspective with the camera almost at ground

level aimed virtually straight upward. Just keep depth of field in mind, and close the aperture enough to ensure that all of the space between the ground and the top of the building is in focus. With ultra-wide-angle lenses (20mm and wider), vignetting (shading at the edges of the frame) can spoil the photo if the aperture is too wide. So – once again – you really need a tripod.

Tips for taking better travel photos

- Pre-trip research is essential
- Work out the best time of day for photographing famous buildings
- Get to know a city on foot
- Use converging lines as part of your composition
- Use raised viewpoints and viewing platforms whenever possible
- Beat the crowds – the early bird catches the worm
- Be in place early for evening shots to make the most of the changing dusk light
- Beware of brightness and contrast inside a building; use indirect flash if necessary
- Practice dealing with extreme lighting conditions at home
- Obtain any permits you need before visiting a site and starting your shoot

Landscapes

Landscapes are the most common type of travel photograph. If you start to see the sun as a kind of floodlight, the clouds and wind as a set and the landscape itself as theatrical, you'll be rewarded with impressive results.

Of the many ingredients in a fascinating landscape photograph, one is particularly important: time. The right light, the right mood, suitable weather – landscape photographers have to be prepared to wait, sometimes for hours, sometimes even for days, because in areas with a highly structured landscape, the view changes from hour to hour, especially at sunrise and sunset. Early morning light is generally very soft, but even the first hesitant rays of sun significantly increase the contrast in a scene.

Therefore, the angle between the photographer and the incident light is crucial. If the sun is rising behind the photographer's back, so that the subject is directly to the west, there will be almost no contours. The sun illuminates the landscape directly and everything looks flat. But if the subject lies in a north-south direction, the light will fall at an angle, giving the landscape contours and allowing the light and dark parts of the image to form a harmonious whole. The higher the sun is in the sky, the weaker the contrast will be and the more ordinary the photo will look.

Big Sur, the famous coast between San Francisco and Los Angeles, is a good exam-

ple. Drive along this stretch of coastline in the morning and you will wonder what there is to rave about. But in the afternoon or evening, when the Pacific Ocean is sparkling and the huge waves look dramatic in the light from the setting sun, it is clear why so many writers have described this place with such intensity and why countless photographers have taken so many spectacular pictures.

Some other places and subjects look their best in vertical midday sun. If you are shooting in a dense forest or jungle, for example, a vertical angle of incidence is not a disadvantage at all, as the branches provide enough light and dark details. And if you are trekking or driving through a steep gorge, the middle of the day is often the only time rays of light reach down far enough.

In many cases, however, the sun is a real "image killer". For example, if you are photographing a landscape from a high vantage point with no sky in the picture, the clouds create blotchy shadows on the ground that spoil the photo and change the visible texture of the landscape.

Correcting Exposure Manually

If, for example, your subject is not well lit, or parts of the subject are brightly lit by a ray of sunshine breaking through the clouds, your camera's automatic exposure systems will often miscalculate. If the brightest part of the frame is not in the center, the camera tries to brighten the darker parts, brightening the already bright areas and overexposing them. The photo turns out flat and does not look at all like the landscape as you saw it.

Manual intervention helps here. Meter the brightest part of the subject using a spot meter and use the resulting value to make your exposure. The camera's meter will indicate underexposure, but the finished photo will reflect the drama that you actually experienced.

The exposure meter has a particularly difficult time metering breaking waves. The white spray tricks it into registering a bright subject, causing it to stop down. But because the sea is quite a lot darker than the spray, the picture will definitely be underexposed if you use an automatic setting. To work around this problem, meter the scene without the white spray, lock the resulting exposure setting and then



In the mountains, there is a very narrow window of time for taking atmospheric photographs, so you need to be in place and ready to capture your subject well beforehand. The dramatic "alpine glow" (shown here in the Dolomites) usually lasts only a few minutes.



Depending on the aperture setting you use, the sun used as a backlight becomes either a bright spot (above, Santorini, taken at f11) or a star (below, Lake Tegern, Germany, shot at f22).



photograph the breaking wave. For this method to work, your camera must have a built-in exposure lock capability.

Shooting Multiple Image Versions

The more extreme the contrast, the more important it is to take a series of shots using different exposure values. In the situations described above, it's a good idea to take shots at higher and lower exposures, using half-stop increments. Experienced professional photographers also use this technique, taking extensive sequences of photos of difficult subjects, and selecting the best ones later on a computer monitor.

Another advantage to having a various exposures to choose from is that you can merge them digitally using HDR techniques. Where there is too much contrast in a scene you can combine the correctly exposed bright parts of one image with the correctly exposed dark parts of another.

Backlighting

Many photographers like the spectacular effects produced by using the sun as a backlight.

Whether in a snow-covered landscape, the desert or the mountains, if you shoot with the sun shining directly into the camera, the light meter will always get confused. Just like our eyes, which react immediately to direct sunlight by closing our eyelids, the light

meter will select the smallest possible aperture and as short a shutter speed as possible – especially if the sun is in the middle of the frame. Extreme underexposure is then unavoidable.

To achieve lighting that portrays the scene the way you actually saw it, meter your subject either without direct sunlight or with only partial sunlight, and use the resulting value for your shot with the sun as a backlight. By the way, the smaller the aperture, the smaller the resulting “sun star” will be.

There is another way of improving your results in situations like this. A graduated neutral density (ND) filter makes it possible to darken the upper half of the photo – and of course also the bottom half, should this be necessary – so as to lessen the contrast. The key is that the filter must be truly color-neutral. Otherwise, the darkened half of the photo will end up with an unwanted and inappropriate color cast.

Shutter Speeds

In landscape photography, shutter speeds affect the technical quality of your results, while depth of field is a more significant creative factor. If you don't use a tripod, you are limited to using the fastest possible shutter speed in order to avoid camera shake. But while using a tripod eliminates the risk of shake caused by the photographer, you are working outside and it cannot do anything about the wind. Having maximum depth of field thanks to a small aperture will be of no

use at all if movement of leaves, branches or flowers causes blur. The only thing to do is to wait for a wind-free moment or find a compromise between the longest possible exposure time and the corresponding aperture setting.

Tips for taking successful landscape photos

- Allow plenty of time
- Make the most of morning and late afternoon light
- Feel the feelings – let yourself experience the landscape
- Look for the best position to photograph from and find out the most suitable time of day for taking photos
- Use a compass to find out the best lighting angles and plan your travels accordingly
- Spend a morning and an afternoon/evening at key locations
- Take special care to choose the best time of day on the coast
- Depending on the subject, use the lighting in the middle of the day too
- Fair weather or foul, make the most of your subject – don't restrict yourself to shooting just on sunny days
- Use depth of field deliberately as a design and compositional tool
- Always use exposure compensation if necessary and, if you are in doubt, take a series of shots with different exposure values
- Choose shutter speeds creatively when composing your photos

People

Faces are fascinating, especially when people are going about their daily lives in a setting that is socially and culturally new to us. Such photos express the character of a country better than almost any other subject. The challenge in this type of photography is less a technical one than one of getting to grips with our attitudes to photographing strangers.

Imagine the scene: midnight mass at a huge cathedral in Germany on Christmas Eve, and a busload of scantily-dressed, dark-skinned people with body paint and bones in their hair rush up to the altar and demand to have their photos taken with the priests.

Sadly, this is not as bizarre as it sounds. I have often witnessed scenes just like this, at festivals in Bali, the Buddhist shrine at Borobudur in Central Java and even at the street cafés found all over Asia, where the insensitive behavior of tourists, usually from Western countries, often causes embarrassment.

What this means for travel photography is that there is no simple recipe, just a few hard and fast rules: respect, consideration, and

empathy are top of the list. You can usually tell by looking at a photo whether the photographer had the courage to interact with the subject or whether the photo was simply “stolen”.

That doesn't mean that that you have to get to know every portrait subject personally. Often, this is simply not possible because of the language barrier. But the language of emotions knows no barriers and you don't have to speak your subject's language to know whether she or he feels good about being photographed. A small gesture, a smile, or a few words in the local language are usually enough to create a connection between a photographer and a potential subject.

Practical Portrait Photography

Medium length (80 to 135mm) telephoto lenses are best for taking traditional portrait photos. In order to get a face to fill a 35mm frame using a 100mm lens, you will need to shoot at a distance of about 120 cm. At this short distance, the subject plane lies within the usable range but the depth of field is quite shallow, even at f8, making it necessary to focus extremely accurately. The additional brightness of large-aperture lenses helps you to focus in this type of situation.

A portrait subject's eyes should always be in focus. Since the field of focus is usually located one third in front of and two thirds behind the subject plane, the tip of your



A person's face – like this Cuban woman in Havana – is often a great deal more interesting than photos of beautiful countryside or famous monuments. This is a good example of a portrait taken using a wide aperture to create an out-of-focus background.

subject's nose and ears will still be in focus if you set focus correctly.

Backgrounds

Portraits are particularly effective if the background is out of focus. This can be achieved by using shallow depth of field or a large distance between the subject and the background. The longer the telephoto lens and the larger the aperture you use, the more ambiguous and abstract the background will be.

We often concentrate too much on the subject at the expense of the background, but asymmetrical textures or – if the aperture is closed down too far – solid objects, can ruin the whole picture. Sometimes all you need to do is step to one side, and the background improves instantly. For training, study portraits that you find pleasing in magazines and books, and try to identify what it is about them that appeals to you.

If you want to show more than just a face, you can use different aperture settings to create different effects. For example, if you are photographing someone in a street café, it can be more effective to have other people partially in focus in the background than to have them become indefinite flecks of color. There are plenty of examples of the way a recognizable background has a positive effect. The main thing is always to be aware of the overall effect of your photo and, especially in the case of portrait photography, not to leave your composition to chance.

People in Action

In relaxed situations, such as at carnivals, festivals and public gatherings, photographing people can be quite risky. As well as looking for spectacular subjects, you have to be aware of your own safety and also look after your equipment, so as not to be trampled by the crowd (at the carnival in Rio), sprayed with beer (Oktoberfest in Munich), or sprinkled with colored powder (holi season in India). In situations like these, an ideal way of photographing individuals or groups of people is to use a wide-angle zoom head-on, getting as close as you dare to the subject. If the movement is coming toward you, as in a procession, you will probably have to move backwards as your subject approaches. Such photos can be very emotive and make viewers feel as if they are part of the action.

Lighting Portraits

Use of light is crucial to a successful portrait. Unlike in a studio, where you can light a face



There are no rules about how to hold your camera when you are shooting portraits, and many great photos have been taken in both portrait and landscape formats. This young Samburu woman in Kenya makes a great subject, whichever way the photo is oriented.

in all manner of ways, outdoors, you are dependent on the light that is available while you are shooting. If you are working with a model, you may be able to decide on the background yourselves and find a spot at the correct angle to the sun. But you will not often be able to influence a scene this directly, and the only variable you can normally change is where you are standing. This makes it all the more important to observe a few basic rules, as outlined below.

Direct, frontal light is unfavorable for portraits, as it makes it impossible for the subject to open his or her eyes more than a slit. It is much better to have the light coming from the side, as this also preserves the shape of the subject's head. However, with lateral light, make sure that there is not too much contrast between light and dark within the frame. Diffuse light from clouds, a cause of concern for landscape photographers, is an advantage for portrait photographers, because it best preserves the natural look of a face. But most photos taken when the sun is high are unsatisfactory: eyes disappear into dark hollows and noses are too brightly lit. It is usually best to shoot in the shade, but make sure that your background is not too brightly lit, or your image will once again contain too much contrast.

Early morning and afternoon are the best times for taking portraits, as the light is usually warmer and produces more pleasing skin tones.

Shooting Formats

You will have to decide whether to hold your camera vertically or horizontally when you are shooting portraits. In my view, there is no point in making a hard-and-fast rule about this, as we do not want to restrict the ways in which we can portray a subject. There are many boring and memorable examples of both types of shot.

Whether you photograph a face tightly cropped, or even curtailed by the upper or lower edge of the frame, depends on your personal shooting style. The only thing that really matters is that you succeed in capturing something of your subject's personality.

Paying for Portraits

It is not uncommon for people to ask for money if you want to take a photo of them. Some tourists comply, feeling that it frees them from the obligation to exchange a few words with the person.

I don't go along with this type of transaction, as it is not about paying an appropriate fee for performing a service. There's no denying that we are far richer than the people we photograph in many of the countries we visit. But a "modeling fee" is appropriate only if you are going to use the photo commercially. If you are taking the photos for your own private use, it is not necessary.

Tips for taking better portrait photos

- Think about, note down and keep an eye out for subjects and situations
- Always make sure you have enough free space on your memory card
- Instead of waiting until the last moment, swap your memory card for an empty one ahead of situations where important subjects are likely to crop up, such as at festivals
- Use 80 to 135mm lenses (35mm equivalent)
- On outings and car trips, keep a standard lens, a short telephoto or a zoom lens mounted on your camera to save time
- If your camera has it, use programmed auto mode for fast-moving situations
- Replace or charge your batteries before a shoot so that they do not go dead at the crucial moment
- As well as words, use non-verbal communication with people you are photographing
- Wear appropriate clothing that does not attract undue attention
- Make sure each lens has a fixed place in your camera bag so that you do not waste valuable time hunting for things
- Pay special attention to your camera bag and equipment in situations where there is a lot of action; otherwise you will be so busy thinking about your subject that you forget to watch out for your gear

Photographing Children

To adults, it seems perfectly normal to photograph children from a raised viewpoint. But the height difference is very real and children have to either look up at the photographer or the proportions in the photo will simply look wrong. It is far more effective and produces more realistic-looking results if you make yourself the same height as your subjects and shoot at child level. When photographing children, I have often found that it helps to let them look through the viewfinder first, so that their natural curiosity is satisfied.



Composition

Selection of detail, the position of the horizon and the focal length of the lens you are using all influence the effect your composition will have. Composition is about creating excitement, using color well and making the most of contrast.

In landscapes, the relationship between the foreground and the background plays a key role, so it is important to think about your priorities for each shot. For example, is the foreground or the background more important to the overall effect of the shot? When you are composing a photo, it helps to use a tripod, because this makes it possible to take your time and compare the different available options.

For instance, a tree can be positioned exactly in the right or left half of the picture, or the horizon moved up or down. The effect of the sky can be assessed precisely, which can be very useful when you are shooting from a height, as leaving the sky out often makes a photo more dramatic.

Elements of a Photo

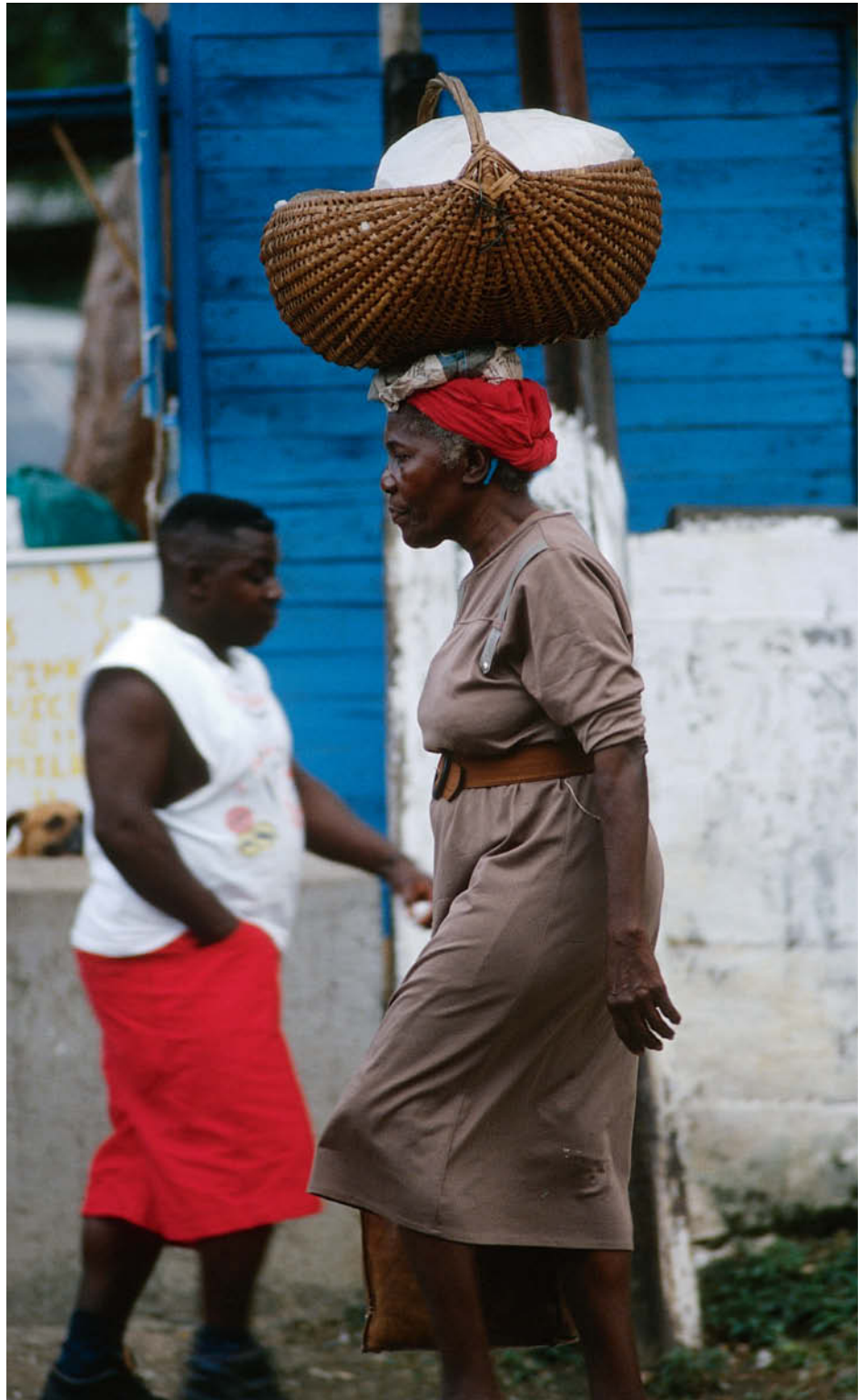
The striking qualities of many photos are not due to a multitude of details but to the photographer concentrating on certain elements of the image, such as color and contrast. If an image contains a field of rape seed in bloom that contrasts with a deep blue sky or a dark forest, the photographer can choose whether to make the yellow, the blue or the green more dominant.

Image Formats

People see the world in a horizontal format, and since landscapes usually involve an expanse of territory, i.e. they are wider than they are high, this is the format most commonly used for landscape photos shot using 35mm equipment.

But don't fall into using a horizontal format automatically just because that's the way we expect to see things. An out-of-the-ordinary format often presents more interesting aspects of a subject and can produce more effective results while you develop your own landscape style.

In Jamaica, serendipity brought together the colors red, white and brown in the passers-by, against a blue background that lends excitement to the overall image.





Frames, like this archway in Volterra, Tuscany, concentrate the eye on the center of the image. If there is too much contrast between light and dark, you will need to use flash.

Use of Space in Photos

Our usual way of seeing things plays an important role in the way we perceive the arrangement of surfaces and space. Our eyes and brain try to make sense of what we are taking in – a vital process, since otherwise we would not even be able to move about easily in our everyday environment. To make this possible, the brain has to be able to process essential visual information at speed, so it follows that the subject is located in the center of the frame in most photos that were taken without much thought for composition.

However, when approaching things artistically, there is always the option of breaking these rules. Dividing the space up deliberately creates tension that is unusual and makes people look more carefully.

The Golden Ratio

The “golden ratio” is a design rule that has been in effect through all eras of art history and seems to have arisen from a human need for harmony. It describes a ratio that produces lengths or surfaces that people feel are particularly harmonious. A landscape photo looks “right” when important lines do not lie in the middle but are located according to the horizontal and vertical lines and points created by the golden ratio.

The golden ratio bisects a line so that the length of the whole has the same relation to the longer part as the longer part has to the shorter part. The “rule of thirds” is a simplified version of the golden ratio for use in everyday photographic situations, and divides the frame into nine rectangles of equal size. The

four corners of the central rectangle then become the anchor points for important elements of the subject.

Shooting at an Angle

As is so often the case, advertising has influenced the style of many forms of expression that mirror the current zeitgeist. A few years ago, advertising campaigns began to feature photos in which the camera was tipped sideways, parts of the subject in the foreground were cut off and all the rules that previously applied went out the window. These “trendy” images set new standards in catalog, fashion and still life photography. Even banks and insurance companies adopted the style to make them seem modern and progressive.

Travel photography, too, with its huge variety of potential subjects and themes, can provide a modern, trendy view of the world. And there is no reason why portraits should always have to be photographed at right angles either. Live scenes shot with the camera held at an angle often have a more dynamic appearance, and even potentially boring group photos can take on a whole new look when tackled in this way.

Overlapping Shapes

If the outline of a shape is seen on a single plane, it gives us no sense of depth. However, if two or more shapes intersect or overlap, we immediately sense depth. Even though parts of the shape that is partly covered are no longer visible, we perceive it as being complete. If, for example, you are photographing a row of trees in a landscape, a simple change of camera position can create a much greater feeling of depth.

Color Theory

The effect of color plays an important role in photographic composition. While blue and green often dominate, the influence of other color elements on these two colors determines the overall effect of an image.

Color can create harmony or tension. Color contrasts can be bold and eye-catching or quiet and unobtrusive. The interplay of shape and color enables us to see things, and the human eye’s ability to distinguish between different levels of brightness and colors is what makes the outlines of shapes visible to us.

Human perception assigns greater relevance to shape than to color. Shapes can be described from memory much more accurately than colors. As an example, a red circle on a yellow background is described primari-

ly as a circle, regardless of what shade of red it is. The primary colors each cover a wide spectrum of different shades: red ranges from deep dark red to light pink, blue from black midnight blue or reddish violet blue to greenish light blue, and so on. So photographers must be aware of the effect that colors have on each other, i.e., the contrast that exists between colors.

The contrast between cold and warm colors creates depth too. Warm colors, which are perceived as active, are more eye-catching, while cooler, more passive colors appear to recede into the background. If you place warm colored objects in front of a cool background, you increase the impression of depth.

Framing Effects

The framing effects produced by archways and windows, or views into the open through doors, turrets and caves make the framed parts of the scene recede into the background. The “frame” is in front of the subject.

The frame element is usually darker than the main subject, and the contrast between light and dark creates depth – a compositional tool that is very useful when photographing buildings or urban situations in general.

Use of Contrast

Light/dark contrast: lighter colors are located at the top of the color wheel and darker colors at the bottom. The proportion of light shades in an image is important to the effect the composition produces. The contrast with dark colors makes light colors seem brighter.

Complementary contrast: complementary colors are those positioned directly opposite each other on the color wheel. Combined in a balanced ratio, complementary colors produces images that radiate harmony.

Cold/warm contrast: of all the color contrasts, the contrast between cold and warm is one of the most powerful. Yellow, red and orange tones are associated with sun and fire and are perceived as warm. In contrast, blue and blue-green tones convey the notion of ice and cold.

The color wheel divides colors vertically into warm and cold, and horizontally into light and dark. The horizontal axis offers the greatest cold-warm contrasts, from blue/green to red/orange. The contrast between warm and cold in all its nuances can be used to great effect in all types of photos.

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Text and photos: Reinhard Eisele



Reinhard Eisele is a qualified designer as well as a photographer and author. His assignments take him all over the world and have included trekking shoots in Sumatra, travel shoots for Geo magazine in Borneo, fashion shoots in Hawaii and sports shoots in the Caribbean.

His clients include advertising agencies, clothing and sporting goods companies, tourism companies, car manufacturers, airlines and publishers. His photos have been published in Stern, Geo, Spiegel, Merian, National Geographic, Bunte, Wave Japan and many other magazines. His Photos are available as stock at a number of international agencies and via his own website, www.eisele-photos.de.

Eisele has written and shot photo books on locations as diverse as India, Hawaii, the Engadin, Tuscany and Bali. He has also published reference books on the subjects of travel, landscape, and architectural photography.



André Kramer

Location, Location, Location

Cameras, camera phones and dedicated loggers record geodata that precisely describes where digital photos were taken, while image management software and Web portals use the same data to provide graphical location information for stored images. Geotags have the potential to become a universal image management tool, just like Exif date and time data.

As the number of images we create and keep increases, effective image management is rapidly becoming an important part of our everyday digital lives. But who wants to spend hours, or even days, manually entering keywords for events, people or places? Amongst the tools now available in addition to Exif metadata and face recognition, geotagging is quickly gaining popularity as a way to identify and catalog images.

Geotags can answer a number of questions, but the central one is always “What is this an image of?” You are sure to be able to answer this from memory for a photo of the Eiffel Tower, but things get more difficult for a picture of your family having a good time. Was it in at your sister’s birthday party? Or at your uncle’s place? Or was it New Year’s Eve after all?

The next interesting question concerns the photographer’s own position in relation to the subject. Was she facing north or south when the photo was taken? And geotagging can be used to draw other, very different conclusions, too. For instance, if a photo shows a tree frog, its geotag can help us to ascertain whether it is a member of a European, Chinese or lesser Asian species.

Looked at the other way around, a location can also serve as the starting point for a search. Most image management software is capable of displaying geotagged locations on a map, making a location-related search the next logical step. A square marquee or a circle drawn around a particular point on a map is an intuitive tool for searching through a collection of images. But only a few programs have implemented this type of functionality, due mainly to a lack of generally available geodata.

In order to use geodata effectively, it first has to be embedded in the relevant image data. Programs like *GeoSetter*, *GPSPhotoLinker* or *RoboGeo* are great for doing exactly that. If you want to tag older, archived images, you will probably have to do so manually using coordinates researched with the help of Google Maps or other, similar services. We will go into detail on this process later.

In nearly all other cases, geodata is provided by the Global Positioning System (GPS). Many photographers carry loggers with them that regularly record GPS data, which can then be loaded onto a computer and synchronized with photos using the time and date as a reference. Accessories are available that perform this process automatically while you are shooting and some cameras even have GPS modules built in. We decided to take a closer look at cameras, mobile phones and accessory devices that are capable of geotagging, and at the Web



The Sony DSC-HX5V has built-in GPS and panorama functionality

services and software packages that support them.

Developed by the US military, GPS currently uses 32 satellites to provide geodata with accuracy to within five yards. It also provides altitude information, but this is not as accurate as the other coordinates it delivers. The system functions regardless of the prevailing weather but does not work inside buildings or in deep gorges.

Recording Position Data

Programs that support geotagging usually write geodata directly into the Exif headers of JPEG or TIFF files, which contain fields designed for exactly this purpose. However, some software has problems writing geodata to RAW files because additional data is recorded in a sidecar file, which results in image metadata being present in two separate locations. This can cause conflicts if you use one program to write metadata and another to read it.

Basic geodata consists of latitude (north/south) and longitude (east/west) coordinates and can be extended to include altitude. Devices that have a built-in compass can also record the direction the device was facing when a photo was taken. Some newer devices are also capable of detecting and recording degrees of inclination.

Coordinates are represented either by decimal numbers that look like this: 52.3803 9.8063, here representing northern (i.e., positive) latitude and eastern (also positive) longitude. The system uses negative numbers to

represent southerly and westerly coordinates. The other, more widespread system uses the cardinal compass points N, S, E and W combined with numbers of degrees, minutes and seconds, for example: N 52° 22' 49" E 9° 48' 23".

The Pioneers

Increasingly, modern cameras have their own built-in GPS receivers. Nikon introduced the world’s first GPS-equipped digital compact in 2008 in the form of the relatively bulky, but solidly built Coolpix P6000. As well as GPS, the camera boasted 13.3 megapixels of resolution and a price tag back then of around US\$450. In view of its high resolution and small sensor, it actually produced relatively little image noise in low light situations.

The Nikon GPS module is activated via the camera menu and updates its position every five seconds. Even if it is switched off from the photographer’s point of view, the module remains active and records its position every 90 minutes. It doesn’t work in buildings, even if you are standing at an open window, and it can take as long as 45 seconds for the camera to lock onto a satellite once you are in the open. One drawback of the system is that it drains the camera’s battery relatively quickly, even if you don’t take any photos, and this is one of the major reasons that there are still so few GPS-capable cameras on the market. In general, the system is too slow to correctly locate your position for a spontaneous snapshot, and writes a meaningless 0.00 0.00 in the appropriate Exif fields if it fails

to log a position in time. In this case, the *Google Earth* pin is displayed in the middle of the Atlantic, somewhere to the south-west of Nigeria at zero degrees longitude on the equator – a place that is almost a second home to geotaggers everywhere.

The Ricoh Caplio 500SE also records GPS data, but with its bulky shape and list price of around US\$1,600, it is not really destined for vacation use. Primarily intended for use on building sites, it is designed to take some knocks – in fact, it is dust and waterproof to IP67 standards. Some say that this camera was developed for military use, and its gray rubber housing and large buttons make it look like a cross between army field gear and a Lego toy. In our test, the Ricoh's prominent aerial allowed it to lock onto positioning satellites from the windowsill. The firmware offers options for writing geodata to an image's Exif header or directly into the image itself. The camera also has a built-in compass, but its 2.5-inch monitor and DOS-like menus make it quite difficult to handle. On the plus side, the large buttons and dials are easy to operate, even if you are wearing gloves.



Nikon's Coolpix P6000 was the first consumer compact on the market with a built-in GPS receiver and writes geodata directly to a file's Exif header

GPS Compacts

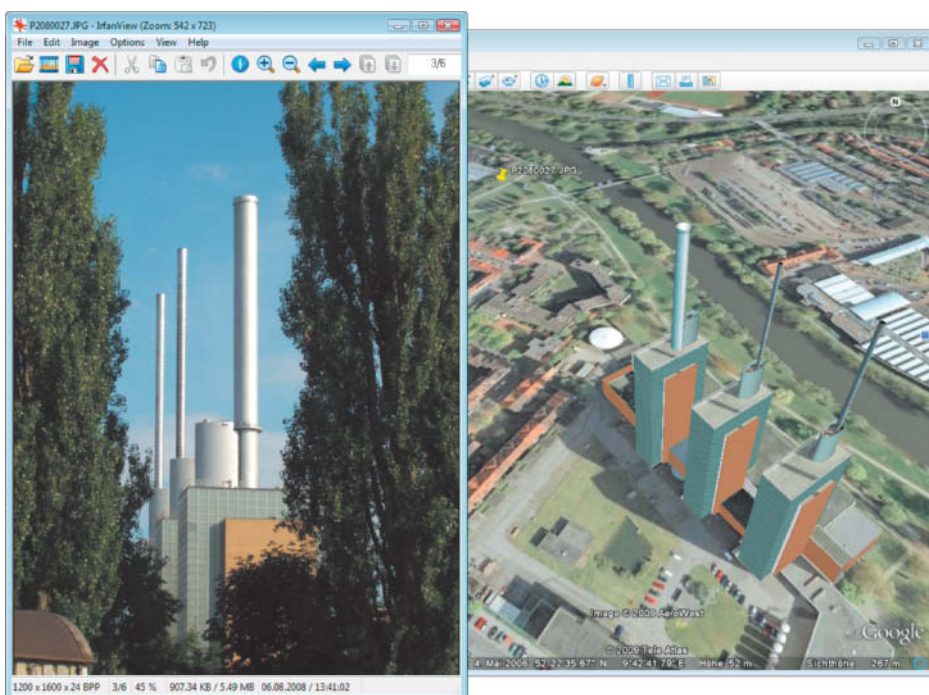
The GPS-capable compact camera market began developing very rapidly in early 2010. Three travel zoom cameras with GPS functionality are currently competing for consumer dollars. The Panasonic Lumix DMC-ZS7 (or DMC-TZ10, as it is known in some mar-

kets), has a rugged metal body in a choice of five colors. The camera's sensor has a nominal resolution of 14.5 megapixels, but only 12 of those actually make up the image data it records, while the rest of its receptors are used to extend the range of its 12x optical zoom digitally to 16x. The shooting format

can be switched between 4:3, 3:2 and 16:9, and video mode allows you to shoot stereo video at resolutions of up to 720p, which the camera then saves in Motion JPEG (M-JPEG) or AVCHD Lite formats.

The Lumix's additional GPS functionality is indicated by a small extension to the top of the camera body that has "GPS" written on it. Once switched on, the unit takes about a minute to find its location, and only works reliably in the open. Once it has been activated, the GPS unit locks onto a satellite at regular intervals and makes short work of a full battery as a result. The camera's firmware makes sure that the GPS unit cannot completely drain the battery, but this is nevertheless a major drawback.

In May, Samsung introduced its own GPS-equipped compact. The HZ35W (or WB650 in some markets) has a metal body, a 12-megapixel sensor and a 15x (24-360mm equivalent) Schneider Kreuznach wide-angle zoom. The 3-inch OLED monitor offers 920,000-dot resolution. The camera is cur-



Geodata in its purest form: IrfanView displays latitude, longitude and altitude data and converts it into Google Earth pins

This Ricoh Caplio 500SE camera is fitted with a GPS module that writes geodata to JPEG Exif headers or directly into the image. This extremely robust camera is primarily designed for documenting building projects.



rently available for about US\$320, which is about US\$80 more than its sister model, the HZ30W (WB600), which doesn't have GPS and sports a conventional LED monitor. The GPS module is built onto the camera's body, which is not especially pretty, but does make it possible to switch the unit off independently from the camera. This unit also takes more than a minute to find its location, which makes it unreliable for snapshot use, although the most recently logged position stays in memory for a while if the camera is switched off.

Samsung offers a set of digital maps for download and installation on the camera, which then use the camera monitor to display a camera icon and an image thumbnail at the appropriate place on the map.

Sony introduced its DSC-HX5V model in spring 2010. The camera has a composite metal and plastic body, a 10-megapixel sensor and a 10x (25-250mm equivalent) optical zoom. It can record Full HD stereo video in AVCHD format, while its monitor's 230,400 pixels provide an image that is of a distinctly lower quality and sharpness than the competition from Samsung. The Sony is currently available for about US\$320. Interestingly, the Sony uses a gray filter that can be swung in and out of the light path instead of a conventional bladed aperture.

The Sony's 1980 × 1080, 50 half-frames per second video capability is a real plus. You can choose between 4:3 (1440 × 1080) or 16:9 (1280 × 720) formats, which both record 25 full frames per second. In addition to the usual geotagging functionality, the Sony also includes a built-in digital compass that saves the direction the camera is facing with the GPS coordinates – a feature that is, as yet, unique among GPS-capable compacts.

The Sony's A-GPS receiver also finds locations faster than the competition, but requires you to download a month's worth of satellite data in advance, which you can then load onto the camera using the proprietary software that Sony includes with the camera. If you follow these steps, the camera knows where it is just 15 seconds after you switch it on. If it cannot locate a data stream, the camera saves the last known location, which is a great help if you are working indoors, but causes problems if you are travelling and regularly change your location. The direction data saved with the GPS coordinates allows you to display your images with additional direction icons at locr.com or in your image management software. Improvements in battery performance mean that more GPS compacts are sure to hit the market in the near future.

Your Friend and Helper

The GPS smartphones we looked at present a more rounded picture. You will normally have your smartphone with you, it can probably shoot photos at between five and eight megapixels, exposure is taken care of by autofocus or auto flash, and GPS is used to tell you where you are anyway. Many smartphones are also capable of using GSM transmitters to triangulate their position, which shortens the time required by the phone to send and receive a position query via the Internet from three minutes to less than one. This "Assisted GPS" system is supported by most new high-end phones.

The first iPhones used the Skyhook system, which uses nearby Wi-Fi routers to triangulate its position. In second-generation devices, this was replaced with a GPS chip which automatically tags photos. The iPhone 4 automatically tags QuickTime movies, too. The 3Gs and 4 model iPhones ask you if you want to allow your phone to use location services when you switch the camera on. If you confirm this, they can find locations everywhere, even indoors. Outdoor locations are not always recorded very accurately, but every JPEG photo automatically gets a GPS tag in its Exif header. We found that GPS was still active after waking the cam-

era from standby. Other smartphones, such as the HTC Desire, are now capable of recording geodata too, but phones that have a camera and location functionality are not necessarily capable of combining the two to perform geotagging. Cellphone engineers are much more involved in developing transmission and reception technology than camera engineers, which is why GPS has been quicker to appear in smartphones than in cameras. However, GPS use in smartphones has always been more oriented toward navigation than to geotagging and it is still not a given that GPS-capable phones can write geotags to the photos they shoot.

The Samsung Jét S8000, the LG Viewty Smart GC900 and the Sony Ericsson C903 all write geotags in photos, but tend to write a row of zeros rather than the last known position if they cannot get a fix on a satellite at the moment you take a picture. These photos are then located in the middle of the Atlantic if you try to display them on a map. The Sony Ericsson C905 can display its current position in Google Maps, but cannot transfer the location data to photos.

All Plugged In

At the time of writing, we hadn't heard of a single DSLR with built-in GPS. But help is at hand – Hong Kong-based Dawntech and Solmeta, as well as Nikon, all manufacture accessory GPS units that can be attached to your

camera's hot shoe. These provide geodata for all Nikon cameras that are equipped with a 10-pin accessory socket. This applies to the D200, the D3, the D2x, the D700 and Fujifilm's S5 Pro, which is basically a rebadged Nikon D200.

Some accessory taggers use a plug that is compatible with the small rectangular socket built into the Nikon D90, D7000, D3100 and D5000 models. These devices then write geodata directly into the metadata in your JPEG or NEF image files. There is also an accessory geotagging module available for the H3D and H4D medium format cameras manufactured by Hasselblad, and the newer H3D II has the module built in. The Nikon accessory units we looked at are unfortunately not designed to transmit geodata directly to the camera via the hot shoe's contacts, and the varying positions of the sockets on the different camera bodies make it quite tricky to handle the camera with the unit attached. The cable on Nikon's GP-1 sticks out of the camera body at 90 degrees, whereas Solmeta and Dawntech both provide angled connectors that save space and make the camera easier to handle when the GPS unit is attached. However, the accessory socket on Nikon's D5000 entry level DSLR is positioned in such a way that the L-plug on the Solmeta N2 points downward, which puts the cable under a lot of pressure. Solmeta has now introduced a dedicated cable for the D5000 that alleviates the problem.

Although the positioning of the cables isn't perfect, the fact that these units don't use the hot shoe contacts means that you can actually use the hot shoe to mount an accessory flash and simply let the GPS unit dangle from its cable if you need to.

The units take two or three minutes to log onto a satellite, depending on the "view" they have of the sky, and an LED on the unit's body lights up when they have found a signal. An additional entry on the camera monitor displays the last recorded position data.

Logging vs. Tagging

The units we tried have different levels of smart technology built in. The Nikon GP-1 and the Dawntech Mini II can only record geodata at the moment the photo is taken, which means that they record no data if you are indoors or between high buildings. The Pro L and Mini 3L models from Dawntech ("L" means "Logger") and the Solmeta N2 and Geotagger Pro models save the last recorded position in memory, which means that, even if the signal drops off, you end up recording at least an approximate location with your photo.

The Pro L, the Mini 3L and the Geotagger Pro also function as simple loggers that record your route at preset distance or time intervals and record these in a track file. The Dawntech "L" models are all equipped with logging functionality, but are a lot more



Compacts with built-in GPS modules: the Samsung HZ35W (WB650), pictured on the left, and the Panasonic Lumix DMC-ZS7 (TZ10) both capture 12-megapixel images with geotags

expensive than the other models in the range. The Pro L is water resistant and is designed for use with Nikon's water resistant cameras, such as the D300. If you have a non-water-resistant camera, you can stick to using the cheaper (non-water-resistant) Mini model. The Pro model also has a "direct start" feature that displays the last known coordinates immediately when you power up your camera.

The major drawback of all these units is the amount of battery power they use while calculating coordinates. The Solmeta devices have built-in rechargeable batteries and can record data for up to 35 hours, whereas the Dawntech devices draw their power directly from the camera battery. This is more critical when you are using a D5000 with its 1000mA battery than when your camera is fitted with a more powerful 1500mA battery like the ones provided as standard with the D90 and the D300. Our tests showed that battery life can be reduced to as little as two days if you use your camera for eight hours per day with GPS. A battery charge can last for more than a week if you are not logging while you shoot.

Earlier camera models, such as the Nikon D200, used the same battery to simultaneously power the camera's metering systems and GPS units, which tended to drain the battery within hours. This battery use was nevertheless only partially due to GPS tracking. The Nikon GP-1's default settings switch the unit off after six seconds to save power. You can work around this by increasing the value for the forced standby time, but the camera's metering system still operates for the whole time the GPS unit is switched on, once again causing fast battery drain. The Someta and Dawntech devices can be switched on and off independently from the camera and function independently from the camera's meter. Remember to always switch off your GPS device at night or at other times when you are not actually shooting.

New Directions

The Solmeta Geotagger and N2 models are also equipped with a compass that records the direction the photographer is facing when a photo is shot. This feature can be really helpful in situations where the location of the subject itself is more important than the



The Nikon GP-1 GPS unit records geodata direct to image files shot using Nikon DSLRs. The unit's cabling is rather bulky and inhibits camera handling.

location of the camera. Programs like *Google Earth* are capable of evaluating directional information and display the direction the camera was pointed as an arrow.

We would like to see programs that also read a photo's Exif data and display the focal length of the lens that was used. The Latest IPTC Core 1.1 metadata specification distinguishes between "Location Created" and "Location Shown" and compass functionality could be used in future to automatically fill out these fields. The German-language "Bildschild" ("image tag") research project (www.bildschild.de) uses the direction information recorded in a photo's metadata to locate interesting subjects that lie in the direc-

tion the camera was pointing. The geodata relating to these found subjects can then be saved as IPTC data at the click of a button.

Dawntech also sells a module for the Canon EOS 40D, 50D, 5D and ID(s) Mark III cameras that records geodata via a USB connection. This system requires the use of an additional Wireless File Transmitter (WFT) that attaches directly to the camera and transmits photos via Wi-Fi immediately after shooting. The WFT costs between US\$600 and US\$900, depending which camera it is fitted to, and the Dawntech module costs an additional US\$170. WFT modules are usually only used in stationary studio or stadium situations in which the location is known anyway,

The Solmeta Geotagger Pro displays signal strength and other information on a built-in LCD display, whereas the Dawntech device has just one small red LED for indicating signal strength



and there is no real use for such a device in a city or the great outdoors. Geotagging is obviously not as important to Canon's developers as it is to Nikon.

The Unleashed unit manufactured by foolography, which uses a similar principle but a very different design, is compatible with all Nikon cameras (from the D20 onward) that have a 10-pin accessory socket. This unit consists of a small bluetooth receiver that is attached to the camera body and which communicates with a separate logger to write geodata directly to JPEG or NEF metadata via the 10-pin socket. The product's developer, Oliver Perialis, uses a Holux M-1200E GPS logger, which is equipped with dedicated foolography firmware that allows the user to operate the camera's shutter release remotely using a POI button on the logger. The Unleashed is available for the D90, the D5000 and the D3100. The entire system might appear bulky at first, but you can always carry the logger itself in a separate pocket and the tiny bluetooth receiver is virtually undetectable when it is attached to the camera body.

Home Tagging using a Computer

There are other hot shoe-mounted devices available for photographers who do not own one of the Nikon cameras supported by the devices mentioned above. These devices function by saving RAW satellite data that has to be converted to GPS coordinates and matched to the appropriate image files later on a computer. The *photoGPS* device manufactured by Jobo records up to 1,000 sets of data, and is triggered via the camera's shutter and the center contact on the camera hot shoe. This solution is, naturally, cable-free. The same device is also marketed by Bilora under the *Photo Geotagger* brand (see also www.u-blox.com) and both cost around US\$90. Once you have uploaded your photos to a computer, all you have to do is attach the logger via USB and start the Geotate software included with the package. The software then calculates the recorded positions from the RAW satellite data and coordinates the results with the camera's time stamp to match the individual sets of coordinates to your photos. The resulting data is recorded directly to the Exif data of JPEG images or in a sidecar file for RAW images. If a sidecar file is already present, the Geotate software overwrites it. If you have an Internet connection, the software also uses the Geonames service to add additional geographic information, such as city, neighbor-



The tiny bluetooth Unleashed module provides Nikon DSLRs with geodata gathered by a separate GPS logger

hood, or state to the file's IPTC metadata and keywords.

Loggers don't suffer from the same start-up lag as taggers, which saves time and battery power. On the other hand, the process of coordinating and matching the logged data on a computer is time-consuming and prone to errors.

Slot-in Taggers

The 8GB Pro X2 SD card manufactured by Eye-Fi costs US\$130 and fits directly into the camera's memory card slot. It functions like a normal class 6 SDHC memory card, but is also capable of transmitting photos via 802.11n Wi-Fi and recording geotags using local Wi-Fi routers for triangulation. You need to activate Eye-Fi cards via the company's website using the card reader and software provided with the package before you can use the Wi-Fi and geotagging functionality. Once inserted into the camera, the card automatically saves all recent photos to your computer as soon as your camera is within range of your Wi-Fi router. The card saves the MAC addresses of nearby routers with every photo, which the software then plugs into the Skyhook Web

service to calculate the photo's location. The resulting data is then written to the photo's Exif header. The geotagging functionality is not consistently reliable and only works with JPEG images. It also only works if you transfer your images to your computer via Wi-Fi. If you use a USB cable to save your images, the geotagging system doesn't kick in.

The Skyhook system only really works in densely populated areas and provides geodata with approximately 25-yard precision, although the system functions indoors as well as out. GPS only works outdoors and uses more power than Skyhook-based systems, but provides geodata that is 10 times more accurate. Our Eye-Fi test card couldn't always find a signal, even in the middle of the city, and we had to keep the camera powered up for quite a time before it located any nearby routers.

The 11n chip built into the card transmits on the 2.4 GHz waveband and achieves a maximum transmission rate of 150 MBit/s. Using the Eye-Fi card didn't noticeably reduce battery power, but using USB 2.0 is much faster. Used with a Nikon D80, the Eye-Fi card took just over 22 minutes to transfer 930 MB of data at a distance of six feet from our router,



Hot shoe-mounted GPS loggers, like these models manufactured by Jobo and Bilora, usually have excellent signal reception, but don't write geodata directly to the camera or your image files

whereas the same camera transferred the same amount of data in less than two minutes via USB. The Eye-Fi's tiny aerial is fairly weak, and we could no longer transmit and receive if there were more than two walls between the camera and the router. The Eye-Fi card uses power from the camera battery, but is not integrated into the camera's energy man-

agement system, which means that the camera is prone to switch itself into standby mode during long transfers. A D80, for example, can be set to a maximum of 30 minutes idle time before it switches to standby.

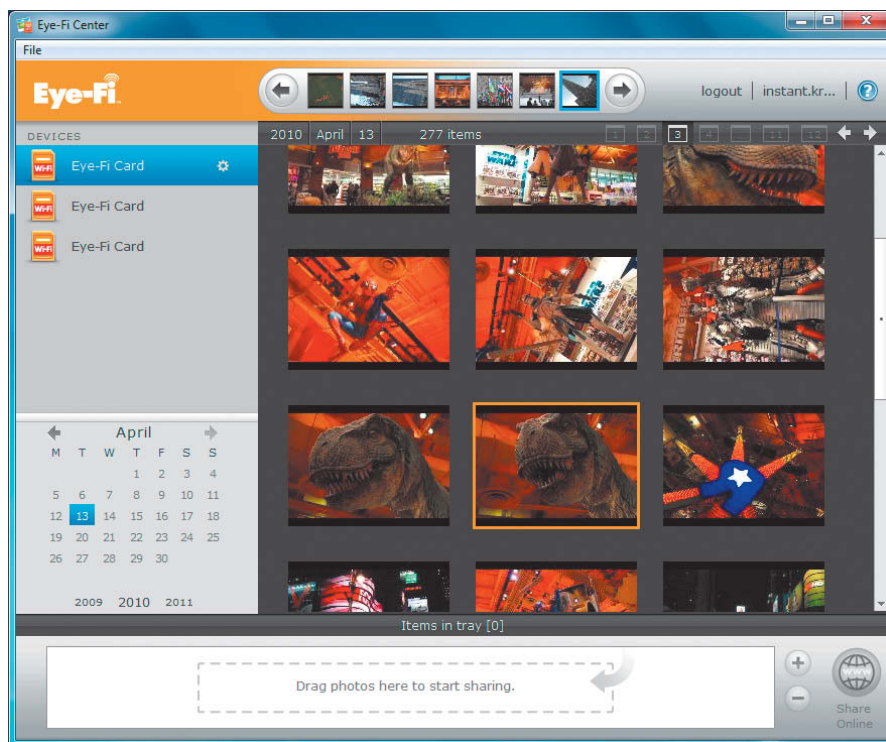
The card's Endless Memory function automatically deletes older photos from the card to optimize the use of memory space, but

GPS Modules for Photographers

Product	GP-1	Geotagger N2	Geotagger Pro	Mini 3L	Pro L
					
Manufacturer	Nikon	Solmeta	Solmeta	Dawntech	Dawntech
Website	www.nikon.com	www.solmeta.com	www.solmeta.com	www.dawntech.hk	www.dawntech.hk
Suitable for use with	Nikon D90, D5000, D200, D300(s), D700, D2X(s), D2Hs, D3(X), Fujifilm S5 Pro	Nikon D90, D5000, D200, D300(s), D700, D2X(s), D2Hs, D3(X), Fujifilm S5 Pro	Nikon D90, D5000, D200, D300(s), D700, D2X(s), D2Hs, D3(X), Fujifilm S5 Pro	Nikon D90, D5000, D200, D300(s), D700, D2Hs, D2X(s), D3(X, s), Fujifilm S5 Pro	Nikon D200, D300(s), D700, D2Hs, D2X(s), D3(X, s), Fujifilm S5 Pro
Features					
GPS chip	not known	SiRF III	SiRF III	SiRF III	SiRF III
Direct write to Exif	✓	✓	✓	✓	✓
Software	- (not required)	- (not required)	- (not required)	- (not required)	- (not required)
Built-in / Camera battery	- / ✓	✓ / ✓	✓ / ✓	- / ✓	- / ✓
10-pin connector: round (D200) / square (D90)	✓ / ✓	✓ / ✓	✓ / ✓	✓ / ✓	✓ / -
Main switch	- (automatic)	✓ (on, off, automatic)	✓ (on, off, automatic)	✓ (on, off, automatic)	✓ (on, off, automatic)
Saves last known position	-	✓	✓	✓	✓
Direct start	-	-	✓	✓	✓
Compass function	-	✓	✓	-	-
inclinometer	-	-	✓	-	-
Logging capacity	-	-	✓ (8 MB: 60,000 data sets)	✓ (8 MB: 260,000 data sets)	✓ (8 MB: 260,000 data sets)
Price (approx.)	US\$190	US\$145	US\$249	US\$150 (plus shipping)	US\$250 (plus shipping)

Eye-Fi cards transmit images wirelessly to a computer via the Eye-Fi Center software. The software uses router locations saved with your photos to calculate geotags, and writes them directly to the image metadata.

Eye-Fi cards combine SDHC flash memory with Wi-Fi functionality and a built-in antenna in an extremely small package



only once they have been safely transferred to your computer. The software can also be set to upload your photos directly to Facebook, flickr, MobileMe or a Picasa Web Album. Eye-Fi cards are not recommended for use with the Nikon D90, and the manufacturer mentions on its website that the camera can produce an error that requires the card to be re-formatted.

Simple Logging

If you already own a digital camera, but you don't want to spend an additional three-figure sum on GPS accessories, you can use a simple logger – available for between US\$50 and US\$100 – to provide geodata for your photos. You can carry a logger in your pocket or attach it to your belt with a carabiner. A logger records your location and a time stamp at preset intervals – often for up to eight hours on a single charge. Be careful to choose a suitable interval to allow the device time to locate its position accurately and to preserve memory capacity. Loggers record better quality data if they have a direct view of the satellite they are logged onto, so the signal will be weaker if you carry your logger in a pocket or a backpack. Loggers don't work indoors, in public transport, under water, in deep gorges or between very high buildings. If you attach your logger to your belt or backpack, it will automatically hang with its aerial pointing upward, resulting in better reception.

The Sony GPS-CS1 was a true pioneer among GPS loggers, but suffers from unreliable reception. The ATP PhotoFinder has its own display and claims to automatically tag JPEG images stored on SD cards. However, in our test, we were unable to read our JPEGs once we had tagged them. The yellow Holux M-241 is a popular logger that is similar to the Sony on the outside, but with better reception and an LED display that shows coordi-

nates and route information. The Wintec WBT-201 (G-Rays 2) and the RoyalTek RGM-3800 are also reliable devices that we can recommend for simple logging tasks.

A word of warning: regardless of whether you record your data from your camera's hot shoe or using a pocket device, synchronizing your geodata with your photos is about as much fun as filling in your tax returns! Loggers save a time stamp taken from the atomic

For a long time, handheld GPS loggers were the only way to record GPS data for use with digital images. They now represent a cheap and practical alternative to hot shoe-mounted taggers.



The *locr GPS Photo* software is free and locates photos using tracking data or maps before uploading them to the *locr* community board

clock built into the GPS satellite, while the Exif metadata stored with image files uses the camera's internal clock. Camera clocks are less accurate than atomic clocks and are often incorrectly set, with no regard for daylight savings or the time zone of the user's current location. If you want to tag your photos accurately, you should synchronize your clocks before a trip as carefully as you would before robbing a bank.

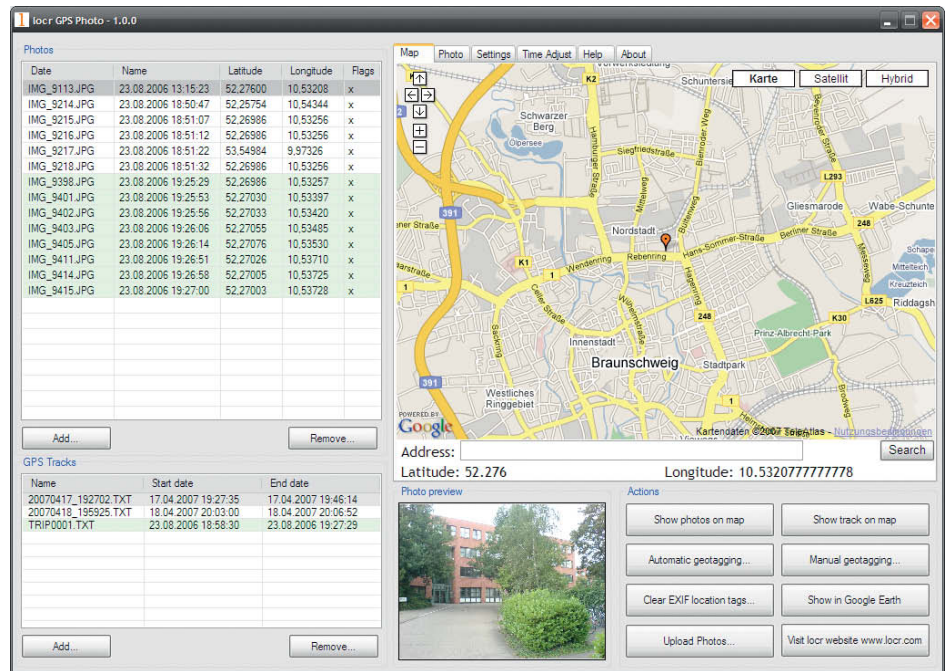
Standardize Me

The various data formats used by different loggers can cause problems too, because geotagging software often only supports a small number of data formats. GPX (GPS eXchange) is an open, XML-based format developed by TopoGrafix and which is in widespread use. The format defines waypoints that can be combined to form tracks and routes. Tracks are paths that have already been travelled, whereas a route can be seen as a kind of suggestion for future action. Unlike a route, a track has a time stamp for each of its waypoints.

The KML (Keyhole Markup Language) and KMZ formats are used for exporting locations to *Google Earth*. The format was invented for use with the Keyhole EarthViewer, which Google purchased and renamed. KML is an XML dialect and is capable of recording place names and descriptions along with location coordinates. The KMZ notation describes ZIP files that can contain image and XML data.

Many navigation devices communicate using the NMEA 0183 standard developed by the US National Marine Electronics Association. The standard transmits location data in plain text (ASCII) form. If a GPS device produces data in a format that your chosen software doesn't support, you need to convert it – for example using the open source, com-

The *GeoSetter* freeware tags photos using location data entered by the user, pins on a map or imported tracking data



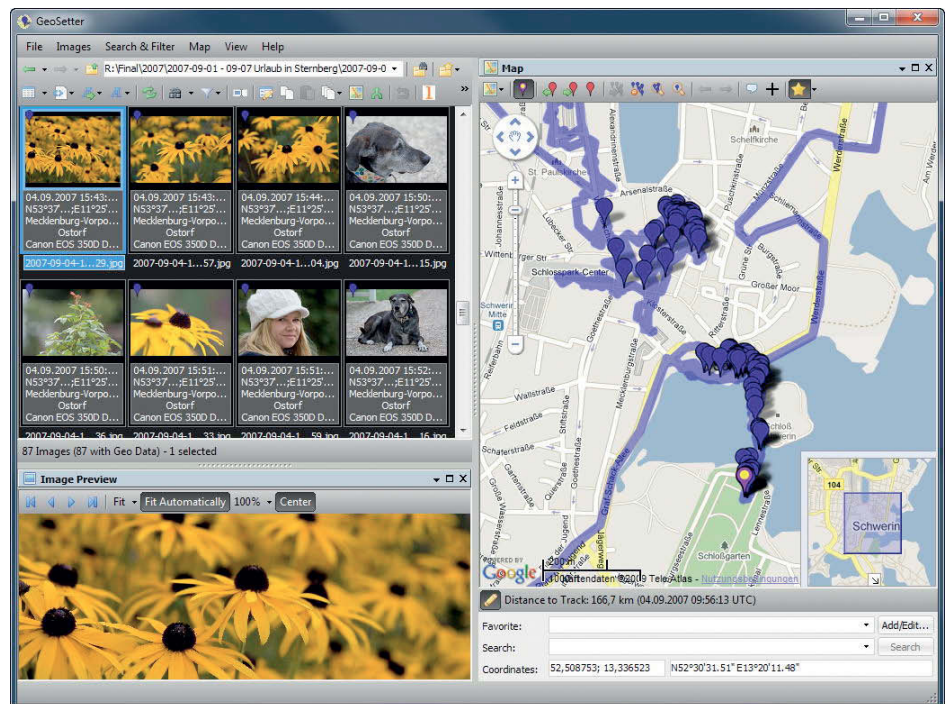
mand-line tool *GPSbabel*. If you are not confident using command-line-based software, you can always have your data converted using an online service like the ones that can be found at www.gpsies.com/convert.do or www.gps-data-team.com/convert.php.

In the Crosshairs

The simplest way to combine photos with logged geodata is using Copiks *Photomapper*,

a program written by Christoffer Hallqvist. This open source software imports GPS tracks (in GPX format) and time stamped JPEG files. It then displays the track in a Google Map and allows the user to match the camera time stamp with the GPS time stamp using the Time Adjustments button. The geodata can also then be written to the photos, which can also be exported to *Google Earth*.

The *locr GPS Photo* freeware was designed primarily for filling the *locr* community with



The *GPSPhotoLinker* freeware can be used to tag JPEG images manually or automatically using an imported track file

tagged photos, but is also very good at combining JPEG image files with NMEA tracks for home tagging use. The program displays tagged photos on a Google Map either in *Google Earth* or via the *locr.com* website, where you can upload photos after a simple registration process. The operators of *locr* also offer versions of their software for use with Windows Mobile, Symbian and Apple iOS devices.

The *GeoSetter* software written by Friedemann Schmidt offers various ways to give your photos geotags. The program uses Google Maps (including satellite view) and open source maps provided by the OpenStreetMap project. *GeoSetter* supports GPX, KML, KMZ and NMEA formats as well as Garmin and Magellan track files. Here, the waypoints are automatically displayed on the embedded map. You can also set a pin on a map and import the location data from the pin into JPEG Exif headers and XML sidecar files using a built-in version of Phil Harvey's *ExifTool*. The program uses the Geonames Web service to import place, state and country names into a file's IPTC data fields

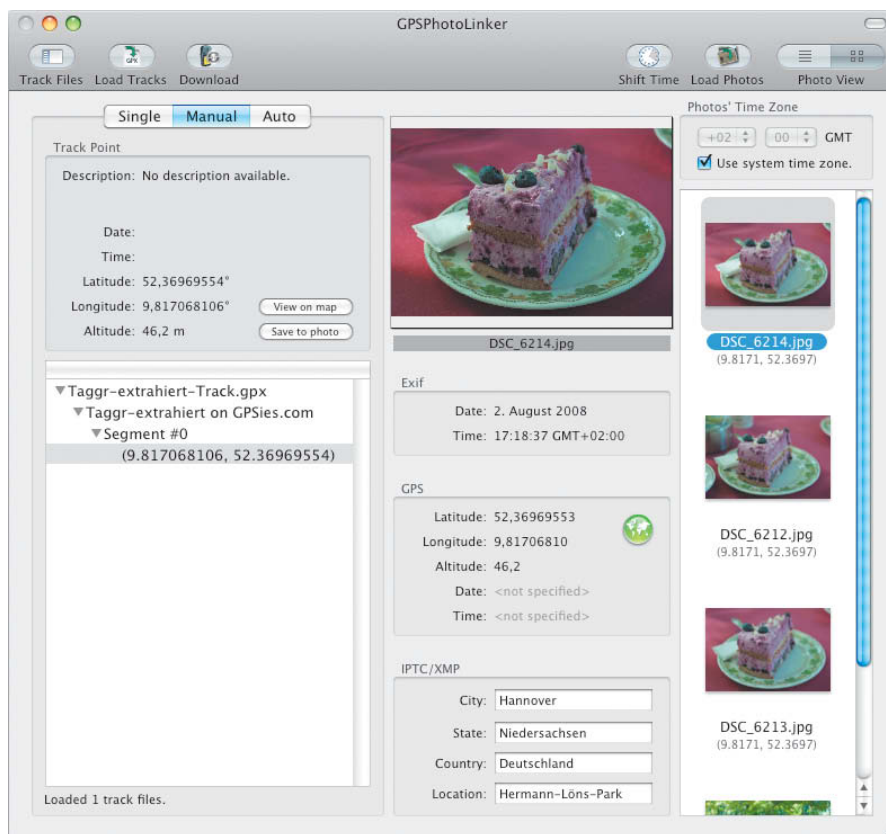
The *RoboGeo* shareware is designed to import Garmin and GPX data to JPEG image files, but can also be used to tag photos manually via *Google Earth*. The program displays altitude and direction data in figures, but doesn't embed maps, making its use rather hit-and-miss. *RoboGeo* is full of good ideas, but is not very intuitive to use.

Mac and Geodata

Mac OS X includes a built-in function for displaying geodata. *Preview* displays images and geodata contained in a file as a crosshair on a world map. Unfortunately, the tool doesn't include zoom functionality for the map, so it is difficult to pinpoint locations precisely.

'09 (and later) versions of Apple's *iLife* suite can use the *iPhoto* app to attach geoda-

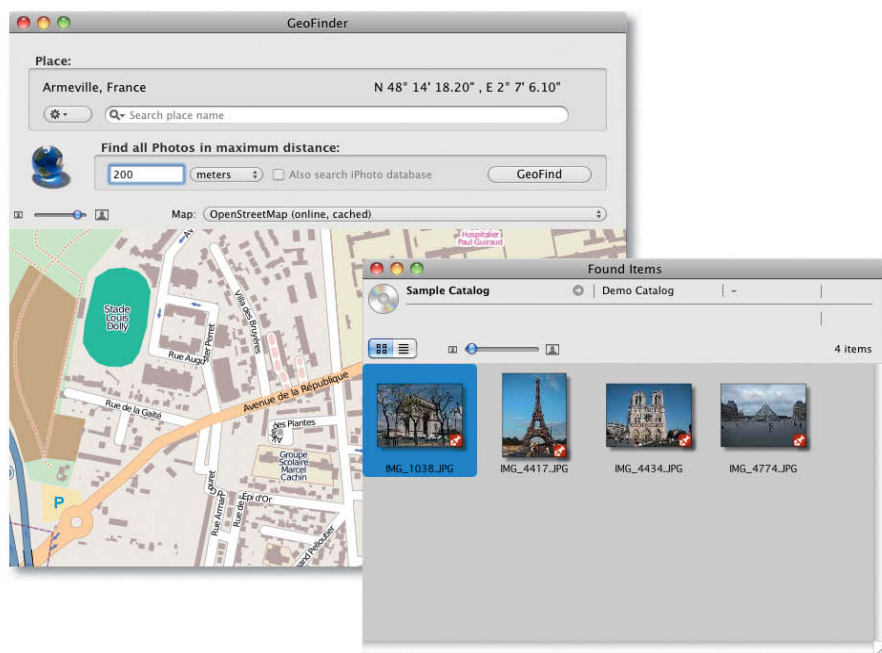
The *CDFinder* software writes geodata to image files, displays locations in *Google Earth* and searches for location-based information



ta to photos by simply clicking on a Google Maps placemark. *iPhoto* saves geodata in its own database rather than as part of the image file and includes only a small Google preview window in the program interface. You can set the program up to write any

saved geodata to your image files during export, although this does involve additional re-sampling.

GPSPhotoLinker is a free and easy-to-use program for linking photos with geodata. The program loads GPX files and links them with



Phase One's *Expression Media* displays geotags as pins on a Bing Map

multiple photos at the click of a button. Time shifts between satellite and camera clocks can be adjusted in hourly intervals and, once again, the Geonames Web service is used to provide additional IPTC information about the locality. The Geonames service doesn't work if you use coordinates taken directly from a map to pinpoint your image.

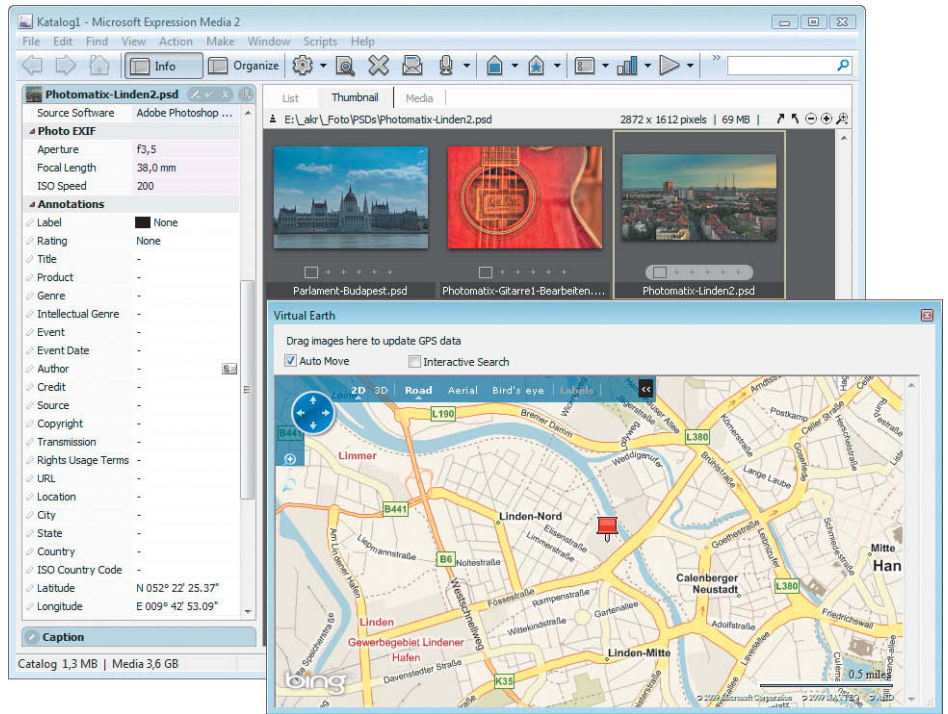
The *HoudahGPS* software package has a modular construction and its interface is color coded to make handling simpler. Photos can be loaded from *iPhoto*, *Aperture* or *Lightroom* libraries, but take care to set the right time zone while you are doing so – the time zone dialog doesn't list the time differences between zones, and only offers a choice of continents and cities. Once you have set the time zone correctly, you can import your GPX track data, which the program then automatically matches to your imported images. The tagged images can then be viewed in *Google Earth* or uploaded to *flickr* or *locr*.

The program *CDFinder* demonstrates very elegantly that you can do more with geotagged images than just display them in *Google Earth*. The program's image manager displays a red icon in the preview window for every image that includes geodata, and allows you to import geodata to non-tagged images by setting a pin on a map. The really interesting feature of *CDFinder* is its ability to search for information about locations within a certain radius of the location of a photo. Optionally, it can also conduct location-based searches in *iPhoto* libraries. The program's author, Norbert Dörner, has written a free extension for the Mac OS X Finder called *GPS-Info*, which displays geodata and includes options for uploading tagged images to *Google Earth*, *flickr*, *Google Maps*, *Panoramio* or *locr*. If your photos include compass data, this determines the flight direction in *Google Earth*.

Using Geotags on the Web

The *locr.com* Web community focuses on geotagged images and already has a library of more than 500,000 photos. The *locr* website automatically displays the location of all

Google's *Picasa* includes embedded Google Maps functionality and allows you to add geodata to your images using a simple mouse click

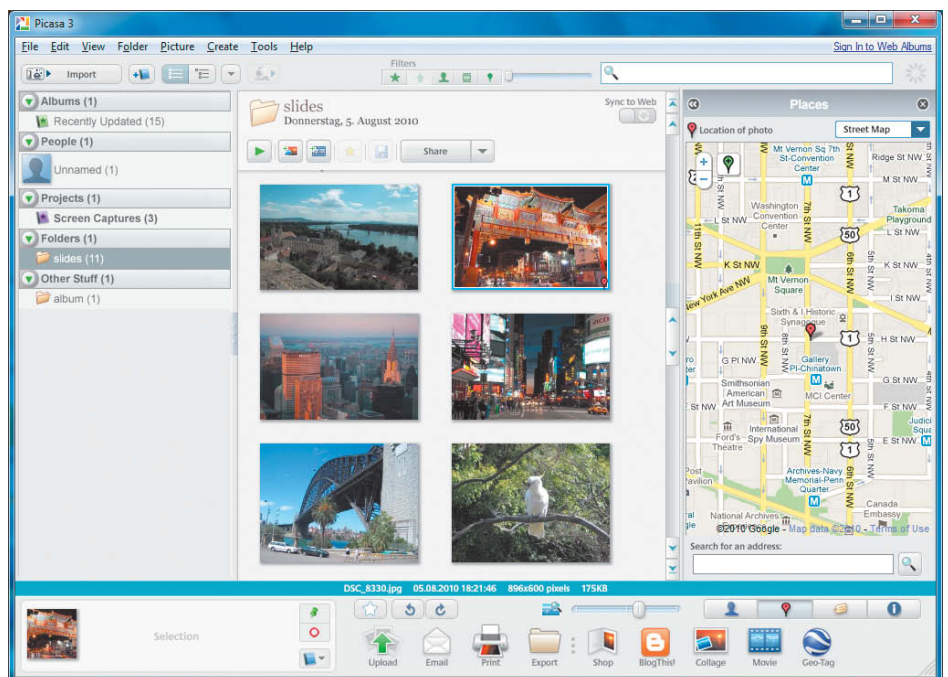


uploaded images on an embedded map, although you can tag uploaded images manually too. Plug-ins are available for simplifying upload from *Aperture*, *iPhoto* and other popular image management programs.

The Map button displays a Google Map and thumbnails of all images taken within the displayed map section. Clicking on a thumbnail displays an enlarged view of the photo. In addition to the map and photos taken

nearby, *locr* also displays Wikipedia articles about nearby places, made possible by the coordinates that are now stored with many Wikipedia entries.

The *flickr* community also uses geotags to catalog a library that it claims contains 126 million geotagged items. This can be useful when you are planning a trip, as you can check out photos not only of popular places, but also of the surrounding area.



The *locr* photo community displays uploaded photos on a map and embeds Wikipedia information about nearby places

Clicking on the map detail button in the *flickr* interface shows a thumbnail of the selected image at the location where it was taken. Users can also apply location data to images by clicking the Organize & Create button and dragging images from the content bar at the bottom of the page to the map in the main window.

Managing Your Images using Geodata

Nowadays, many image browsers and image management systems support geodata. The *IrfanView 4* image browser and the *Adobe Photoshop Lightroom 3* RAW workflow package only display basic coordinates, although *IrfanView* can also display locations in Google Earth as pins or, if the file includes compass data, as arrows. Clicking on the coordinates in *Lightroom* opens Google Maps. *Lightroom's* major competitor, Apple *Aperture*, is also an all-in-one workflow tool, but puts a greater emphasis on image management than the Adobe program, and includes the face recognition and geotagging functionality that many Apple users know from *iPhoto*. *Aperture* includes embedded Google Maps functionality and you can match photos with location data either by dragging them to a map or by applying coordinates saved using a logger. *Aperture* supports the GPX format but not KML. When you are tag-



ging images, the time recorded in a file's Exif data generally has to match the satellite time logged with the position coordinates. If the times don't match, things can quickly get quite complicated. Apple has come up with a clever solution to time shifts: if you position a single photo from a shoot at a selected place on a track, the rest of the images in the batch are automatically positioned relative to the

first image. Unfortunately, *Aperture* saves geodata in its own database, and not in a sidecar file, which makes it less universally useful than we would like.

The *Expression Media* image management package (recently sold to Phase One by Microsoft) has embedded Bing Maps functionality – the arch-rival of Google's Maps service.

Geotagging Software				
Product	GeoSetter 3.3	GPSPhotoLinker 1.6	HoudahGeo 2.6	locr GPS Photo 1.2.4
Manufacturer / Author	Friedemann Schmidt	Early Innovations	Pierre Bernard	locr GmbH
Website	www.geosetter.de	www.earlyinnovations.com	www.houdah.com	www.locr.com
System requirements	Windows	Mac OS X 10.5 and higher	Mac OS X 10.4 and higher	Windows XP/Vista
Features				
Track file import: GPX / KML / NMEA / other	✓ / ✓ / ✓ / Garmin, Magellan	✓ / - / - / Garmin, Magellan, Wintec	✓ / - / ✓ / Garmin, Magellan, Holux, Sony, TCX	- / - / ✓ / -
Photo Import: JPEG / TIFF / RAW	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓, from iPhoto, Aperture, Lightroom	✓ / - / -
Photo Export: JPEG / TIFF / XMP / RAW	✓ / ✓ / ✓ / ✓	✓ / ✓ / - / ✓	✓ / ✓ / ✓ / ✓	✓ / - / - / -
Manual tagging	Google Maps	Manual only	Google Maps/Google Earth	Google Maps
Other geodata: altitude / compass data	✓ / -	✓ / -	✓ / ✓	- / -
Export to Google Earth (KMZ)	✓ (KMZ)	-	✓ (KML, KMZ)	✓ (KML)
Upload: locr / flickr / Panoramio	✓ / - / -	- / - / -	✓ / ✓ / -	✓ / - / -
Time shift	Day, hour, minute, second	Time zone (hourly)	Seconds	Day, hour, minute, second
Exif date change possible	✓ (with time shift)	✓ (with time shift)	✓ (manual, with time shift)	-
Embedded maps	Google Maps, OpenStreetMap	-	Google Maps	Google Maps
IPTC place names	via Geonames	✓	✓ (Reverse geocoding)	-
IPTC editor	✓ (comprehensive)	✓ (place names only)	-	-
Additional features	Altitude can be queried online	Place name tag removal	via CDFinder, search in Panoramio and locr	Place name tag removal
Price (approx. US\$)	Free (also included on our DVD)	Free (also included on our DVD)	US\$30	Free

The flickr interface allows you to search for images using keywords and to click on tagged photos using a map

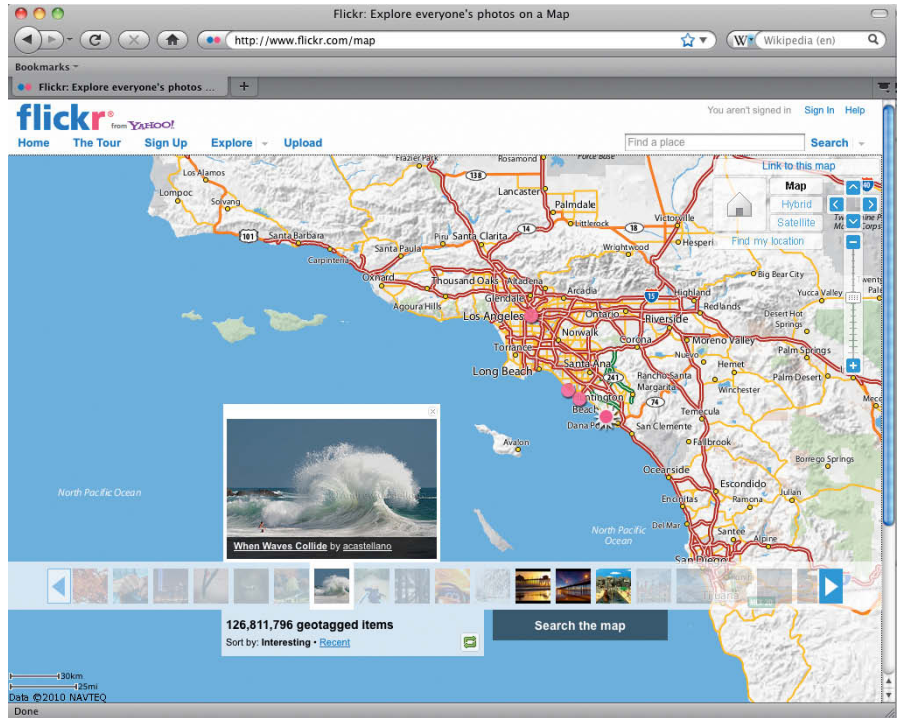
Locations are displayed as pins in the program's interface, and you can also have the program transfer the coordinates of pins that you position yourself to an image file. At the time of writing it was still not clear whether Phase One intends to integrate *Expression Media* into its well-known *Capture One* image processing package.

Google's *Picasa* image management software includes a dedicated Google Maps window in its interface and allows you to add geodata to your images using a simple mouse click. *Picasa* uses a confirmation dialog to ensure that you are matching the image to the correct location before writing geodata to the image file. Up to version 3.5, *Picasa* used *Google Earth* for reference and a floating thumbnail window to add coordinates to images.

Fotostation and *IDImager* use the same process to add tags. The *Studioline Photo Classic* package even has a Geotagging command in its main menu that allows you to drag preview thumbnails to Google Maps. The software then automatically calculates the appropriate coordinates and adds city, state and country information the file's IPTC data.

The Future of Geotagging

Geotagging is still something of an avant-garde pastime and many image management and presentation programs still don't



support the use of geodata, probably due to the lack of standardized data formats. Geotagging will only become part of the digital photographic mainstream when cameras automatically know where they are located. The speed of development of digital photo technology combined with the error-prone nature of GPS technology has, as yet, kept Nikon from taking the plunge and building GPS technology into its high-end DSLRs.

However, this could all change soon. The chip manufacturer SiRF has been manufac-

turing the fast, small and energy-efficient SiRFstar IV range of GPS chips since late 2009. These devices supposedly recognize their location without having to remain switched on and logged onto a satellite. Many GPS devices still use the power-hungry third generation SiRF chips, making it possible that your camera will run out of juice just when you really need it.

Newer GPS-capable compacts are still battling with the reduced battery life that GPS usage causes. The first models that remembered their last known position and devices with built-in compass functionality were only introduced about two years ago. The first hot shoe-mounted track loggers were introduced by Dawntech in 2009. The first batch of loggers to hit the market in 2010 still don't use fourth-generation SiRFstar technology, but the market is nevertheless hotting up. Once camera manufacturers begin to build GPS functionality into their cameras, the software manufacturers are sure to follow with increasingly useful and powerful applications.

Manual geotagging is still too complex and unreliable to be anything more than a niche hobby. But today's GPS enthusiasts are the ones who are paving the way for the mass market. They are testing processes, developing software and gearing us up for a world in which every digital camera has built-in GPS and where geotags are the most natural graphical map search tool that we can imagine.

(keh) **ct**

	Photomapper 0.7	Pro Photo Tools 2.2	RoboGeo 5.6
	Copiks	Microsoft	Pretek
	http://software.copiks.com/photomapper/	www.microsoft.com/prophoto	www.robogeo.com
	Windows	Windows	Windows 2000/XP/Vista
	✓ / - / ✓ / HST	✓ / ✓ / ✓ / LOG	✓ / - / ✓ / Garmin, OziExplorer
	✓ / - / -	✓ / ✓ / -	✓ / ✓ / ✓
	✓ / - / - / -	✓ / ✓ / - / -	✓ / ✓ / - / -
	-	Virtual Earth	Google Earth
	✓ / -	- / -	✓ / ✓
	✓ (KMZ)	-	✓ (KML, KMZ)
	- / - / -	- / - / -	- / ✓ / -
	Hour, minute, second	-	Seconds
	-	✓	✓
	Google Maps	Virtual Earth	- (opens Bing MultiMap in browser)
	-	via Windows Live Local	-
	-	✓ (comprehensive)	✓ (simple)
	-	Place name tag removal, rotate photo	File renaming, write geodata to image
	Free (GPL also included on our DVD)	Free	US\$40



Dr. Klaus Peeck

Interchangeable-lens Cameras

for beginners and experienced hobbyists

This issue's camera test covers the Canon EOS 60D and Nikon D7000 prosumer DSLRs, as well as the Nikon D3100 entry-level model. We also take the new Olympus PEN E-PL1 for a spin and take an in-depth look at Sony's ground-breaking Alpha 55 fixed-mirror DSLR.

The Sony Alpha 55, a new addition to the current crop of interchangeable-lens cameras, is built around a fixed, semi-translucent mirror. This mirror allows approximately two thirds of the light entering the lens to reach the image sensor, while the other third is diverted toward the dedicated phase detection AF sensors built into the top of the camera body. It also allows the camera's 16-megapixel CMOS sensor to produce a constant live view image on the monitor or in the 1.15-million-dot electronic viewfinder. The viewfinder can be magnified, brightened or dimmed as necessary, but nevertheless tends to display slightly over-saturated colors. It can also be used to display additional camera status information and an artificial horizon.

Semi-translucent Mirror

The concept of a semi-translucent mirror isn't completely new: it was first seen more than 20 years ago in the analog Canon EOS RT. The system provides an enormous gain in shooting speed, as only the shutter has to move between shots. The A55 can shoot up to 10 frames per second, enabling the user to shoot handheld 3D panoramas and ultra-fast multiple exposure sequences that can be merged into a single, low-noise image. The downside of this high-speed capability is that live view is deactivated during shooting. The reduced amount of light that reaches the sensor didn't have any obvious effects on exposure during our tests. The camera's noise characteristics are typical for its class, and outdoor shots taken at ISO 400 as well as non-critical subjects

shot at ISO 800, or even 1600, produced perfectly acceptable results. Autofocus worked very well, even in low light situations. The Sony is solid and easy to handle. Our only gripe concerns the four-way controller, which is too deeply recessed into the camera body, making it difficult to operate by touch. Building a combined battery/memory card slot into this class of camera is simply bad form.

Micro Four Thirds

The Olympus PEN E-PL1 has no dedicated AF sensors, but focuses speedily enough using the tried and trusted contrast detection system and its 12-megapixel Four Thirds format sensor. Not as highly featured as its sister models, the E-PL1 is designed as a value entry ticket to the PEN camera world. The body is made of plastic with metal accents and has a user interface without the control dials used in the more expensive PEN models. The camera is operated using two sets of four shortcut buttons and "live control" icons arranged along the edges of the monitor. The system is easy to use once you get used to it. Another interesting feature is the fully automatic "live guide" system that uses sliders on the monitor to make quick adjustments to settings such as brightness, saturation and depth of field. The monitor's 2.7-inch size is well suited to its 230,000-dot resolution. An electronic, hot shoe-mounted viewfinder is available as an accessory and, unlike the other PEN models, the E-PL1 also has its own built-in flash unit.

The Micro Four Thirds concept is mirrorless, making it possible to mount lenses with



The c't test shot contains a number of serious technical challenges as well as some random objects that were selected for their high recognition value. The details mentioned in the test results are outlined in red.

their rear element extremely close to the image sensor. This makes the camera body and the lenses that go with it extremely compact. Fitted with its kit lens, the E-PL1 looks like a large compact, even though its sensor is only 40 percent smaller than the APS-C sensors used in many high-end DSLRs. In our test, the Olympus produced good detail and very little noise at ISO 400 or 800. The kit lens was sharp throughout its zoom range and produced well-defined image detail.

Continued on page 71

Interchangeable-lens Cameras – Test Results, Part 1

	Sensor Resolution [lp/h]	Relative center resolution (ISO 100, wide-angle) / sensor resolution [%]	Center resolution (ISO 100) [lp/h]	Center resolution (ISO 400) [lp/h]	Center resolution (ISO 1600) [lp/h]	Center resolution (ISO 3200) [lp/h]	Center resolution (ISO 6400) [lp/h]	Center resolution (ISO 12800) [lp/h]
Canon EOS 60D with EF 50mm f/2.5 Compact Macro	1728	87	1509	1413	1317	1202	1162	1003
Nikon D3100 with AF Micro-Nikkor 60mm f/2.8D	1536	88	1353	1256	1103	1141	1133	1122
Nikon D7000 with AF Micro-Nikkor 60mm f/2.8D	1632	87	1416	1332	1124	1142	1133	1100
Olympus PEN E-PL1 with M. Zuiko ED 14-42mm f3.5-5.6	1512	93	1399	1362	1337	1113	–	–
Sony SLT-A55V with Sony/ Minolta AF 50mm f/1.4	1632	89	1448	1408	1205	1235	1134	881

Resolution was determined visually in units of line pairs measured over the height of the image [lp/h]. The larger the value, the sharper the image.

Interchangeable-lens Cameras – Test Results, Part 2

	Contrast range/subject range ISO 100 [in f-stops]	Contrast range/subject range ISO 400 [in f-stops]	Contrast range/subject range ISO 1600 [in f-stops]	Contrast range/subject range ISO 3200 [in f-stops]	Contrast range/subject range ISO 6400 [in f-stops]	Contrast range/subject range ISO 12800 [in f-stops]	Real subject range [tonal values]	Color Checker SG Δ E
Canon EOS 60D with EF 50mm f/2.5 Compact Macro	9.7	9.7	9.0	8.0	7.0	6.7	255	8.3
Nikon D3100 with AF Micro-Nikkor 60mm f/2.8D	9.0	9.3	8.7	8.0	7.3	6.3	254	8.1
Nikon D7000 with AF Micro-Nikkor 60mm f/2.8D	9.7	9.3	9.0	8.7	8.0	7.0	250	8.1
Olympus PEN E-PL1 with M. Zuiko ED 14-42mm f3.5-5.6	9.0	8.3	7.0	6.7	–	–	253	7.1
Sony SLT-A55V with Sony/ Minolta AF 50mm f/1.4	9.7	9.0	9.3	8.7	7.7	7.0	255	7.3

The logarithmic density, D, represents the camera's dynamic range in terms of the ratio between the brightness of the subject and the corresponding recorded tonal values. Higher values are better. Real subject range represents the range of tonal values contained in an 8-bit rendition of a test image.



Canon EOS 60D

Large DSLR with an 18-megapixel CMOS sensor, flexible three-inch monitor, fast continuous shooting and Full HD video in a plastic body.

Good: Good handling, rubberized body. Two command dials, customizable buttons. Clear menu structure with one screen per tab. User-configurable "My Menu" tab. Quick control screen accessible via the **Q** button. High-resolution three-inch monitor with large angle of view. Live View with quick or contrast detection AF and digital spirit level. LCD control panel. Large, bright viewfinder. Autofocus with nine cross sensors – very fast with USM lenses. Approximately 5fps continuous shooting, large memory buffer and short image save times. Program Shift. "Creative Zones" with visual assistance. Auto ISO upper limit can be set by user. Shutter speeds down to 1/8000 s and 1/250 s flash sync. In-camera RAW processing. Usable built-in flash with short charge time and wireless slave control. White balance with fine-tuning and Kelvin settings. SDXC-compat-

ible. Powerful battery with optional battery grip. 30fps video. Stereo microphone socket.

Not so good: Plastic body. Locking control dials with end stops. Quick control dial with too many options. Multi controller spongy and imprecise. Main control buttons difficult to operate by touch. Viewfinder display deactivated in continuous mode. Slow Live View AF. Kit lens loud and not USM. Loud mirror. Rudimentary self-timer.

Test results: Best maximum contrast of all cameras tested up to ISO 400, and still good at ISO 1600. Great noise characteristics up to ISO 400, little visual noise up to ISO 1600. Test lens produces 87 percent sensor resolution at ISO 100, 76 percent at ISO 1600 and 58 percent at ISO 12800. Short shutter lag.

Image quality: Tested using an EF-S 18-135mm f/3.5-5.6 IS lens: bold, but neutral colors in daylight. The orange sticker in the test photo turned

out bright orange. Slight underexposure. Gray wedges uniform from step 16 onward. Well-defined detail. Image noise up to ISO 200 very slight, from ISO 400 upward, less texture and dark grays grainier. More noise and less sharpness at ISO 800. Color noise prevalent in dark grays at ISO 1600, with sharpness drop-off and lack of detail in textures. Strong color noise and hot pixels. Some fringing on the edges of the sieve, the Siemens star and the text samples. Some fringing can be compensated for using the in-camera database.

Outdoor shots are color neutral and well-exposed. Good detail at smaller apertures. Good definition for an 18-megapixel sensor, but limited by the kit lens, which produces obvious chromatic aberrations. Insignificant noise up to ISO 400, acceptable around ISO 800, thereafter problematic.



ISO 100



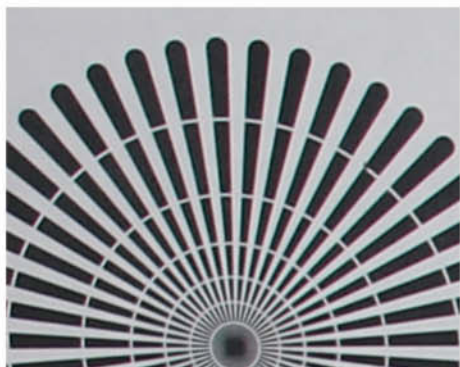
ISO 200



ISO 400



ISO 800





Nikon D3100

An ergonomic and quiet entry-level DSLR with a 14-megapixel CMOS sensor. With live view, Guide Mode and Full HD video.

Good: Compact and easy to handle with a good grip and thumb pad. User-friendly interface with large, easy-to-use control dial. Low-profile but precise multi controller. Customizable buttons and separate release-mode dial. Quick settings via the monitor and the **info** button. Monitor with large angle of view and automatic rotation function. Dedicated live view button and assisted *Guide* exposure mode. Good pentaprism viewfinder for a camera in this class. Fast, precise wide-angle AF with the kit lens. Very little mirror noise. 3fps continuous shooting with large memory buffer. Programmed auto mode with shift function. Auto ISO upper limit user controllable. Built-in *D-Lighting* automatic exposure control. White balance fine-tunable. SDHC and SDXC-compatible. Full HD video with constant AF. HDMI and GPS connectors.

Not so good: Glossy, low-resolution, three-inch monitor. No control panel. No shortcuts on the multi controller. Option lists too long in the main menu. Live view AF slow due to lack of dedicated sensors. Rudimentary self-timer. Memory card slot cover loose. No infrared remote control facility. Maximum video clip length 10 minutes at 24 fps.

Test results: Very good contrast up to ISO 800 – best results at ISO 400. Good signal-to-noise ratio up to ISO 400. Visual noise very low up to ISO 400 and still good up to ISO 3200. Eighty-eight percent center resolution at ISO 100, and a constant 72 to 74 percent at ISO 1600. Average shutter lag.

Image quality: Tested with an 18-55mm f/3.5-5.6G VR AF-S DX Nikkor. Cool but correct colors for the c't test shot in daylight – the orange test sticker is bright but has a slight pink tinge. Fairly good sharpness at small apertures. Detail only average for a 14-megapixel sensor. Matrix me-

tering with obvious underexposure. Gray wedges poorly defined from step 14/15 onward. Very low noise at ISO 100 and ISO 200 and good noise compensation at ISO 400 with only slightly reduced sharpness and detail. Noise compensation electronic from ISO 800 onward, and obviously increased sharpness and brightness noise at ISO 1600. Detail and sharpness fall off rapidly at ISO 3200, with frayed edges and grainy noise artifacts. Reproduction quality above ISO 3200 generally poor. Some fringing.

Outdoor colors good. Kit lens produces only average detail and sharpness, even stopped down. Generally balanced exposure with good contrast. Low noise up to ISO 400, acceptable noise levels at ISO 800. Good fringing compensation.



ISO 100



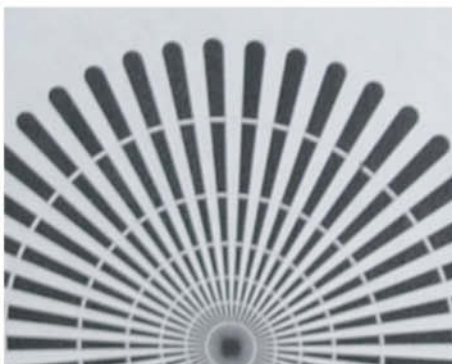
ISO 200



ISO 400



ISO 800





Nikon D7000

Large, highly configurable DSLR with a 16-megapixel CMOS sensor, full-frame viewfinder, 39-point AF and high-resolution monitor in a dust and water resistant magnesium body.

Good: Body easy to handle and highly rubberized. Highly configurable, easy-to-use controls. Dual-level mode dial and small, precise multi selector. Dual command dials at front and rear and some quick settings available via the excellent 3-inch, 921,000-dot monitor. Matte monitor bright and sharp with large angle of view, separate cover, and artificial horizon option. Comprehensive control panel. Accurate 39-point AF with fine-tune and override options. AF with kit lens fast and quiet. Optional *Quiet* shooting mode. Sophisticated multi-mode self-timer and interval timer. Fast continuous shooting mode. Exposure settings precisely fine-tunable. Programmed auto mode with shift function. Upper Auto ISO limit user-controllable. Dual auto white balance settings, with fine-tuning

and Kelvin settings. Short flash charge time, strobe flash, manual flash power settings, wireless flash control. Dual SDXC-compatible memory card slots. Powerful standard battery, optional battery grip. Microphone and GPS connectors.

Not so good: Large choice of functions leads to complex menus with up to six screens. ISO setting and shots remaining cannot be simultaneously displayed in the control panel. Depth-of-field preview button awkward to use and can be operated by accident. Maximum 24 fps for full HD video.

Test results: Excellent contrast right up to ISO 1600, only moderate drop-off at ISO 6400. Best signal-to-noise ratio at ISO 400 and still acceptable at ISO 3200. Visual noise characteristics very good up to ISO 800. Test lens produced 87 percent contrast at ISO 100 and 82 percent at ISO 400, thereafter with noticeable drop-off. Quick power-on and very short shutter lag.

Image quality: Tested using an 18-105mm f/3.5-5.6G ED VR AF-S DX Nikkor. Excellent color reproduction in the c't test shot with the sticker showing up slightly pink. Good definition and sharpness stopped down in daylight. Wide apertures produced poorly-defined image corners. Great exposure, possibly very slightly underexposed. Very few moiré effects and well-compensated chromatic aberrations. Clean, low-noise images at ISO 100 and ISO 200. ISO 400 only slightly less smooth. Grainier images at ISO 800, but still sharp and well defined. Textures still faithfully reproduced at ISO 1600, but with brightness noise that increases at ISO 3200. Excellent overall reproduction. Sharpness and detail start to drop off at ISO 6400, where blue-colored artifacts begin to appear.

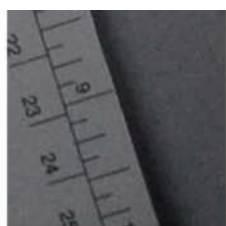
Outdoor sharpness excellent in daylight at medium focal lengths and at all but the widest apertures. Exposure metering slightly erratic, with matrix metering often overexposed. Noise levels at ISO 800 very good, and still acceptable at ISO 1600.



ISO 100



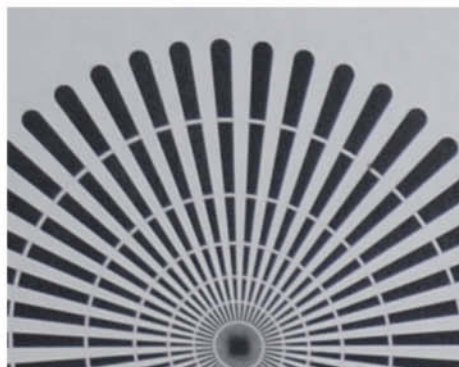
ISO 200



ISO 400



ISO 800





Olympus PEN E-PL1

Extremely compact mirrorless camera with 12-megapixel Four Thirds format sensor. With built-in flash and simple user interface. "Economy" PEN model.

Good: Body in compact style with rubber grip on the battery compartment. Great handling for its size. CMOS sensor with ultrasonic self-cleaning and sensor shift image stabilization. Small, clearly labeled mode dial and well-organized buttons. Matte monitor with large angle of view. Clear main menu, shortcut menus, and *Live Guide* mode make it easy to operate. Kit lens fast and quiet. Kit lens can be collapsed to save space. Fast startup. Program mode with shift function. Upper Auto ISO limit user-controllable. White balance with fine-tuning and Kelvin settings. Short flash charge time, flash with a choice of power settings and wireless slave control. TTL flash control and 30fps video.

Not so good: Low-resolution, 2.7-inch monitor. Viewfinder (optical or electronic) optional.

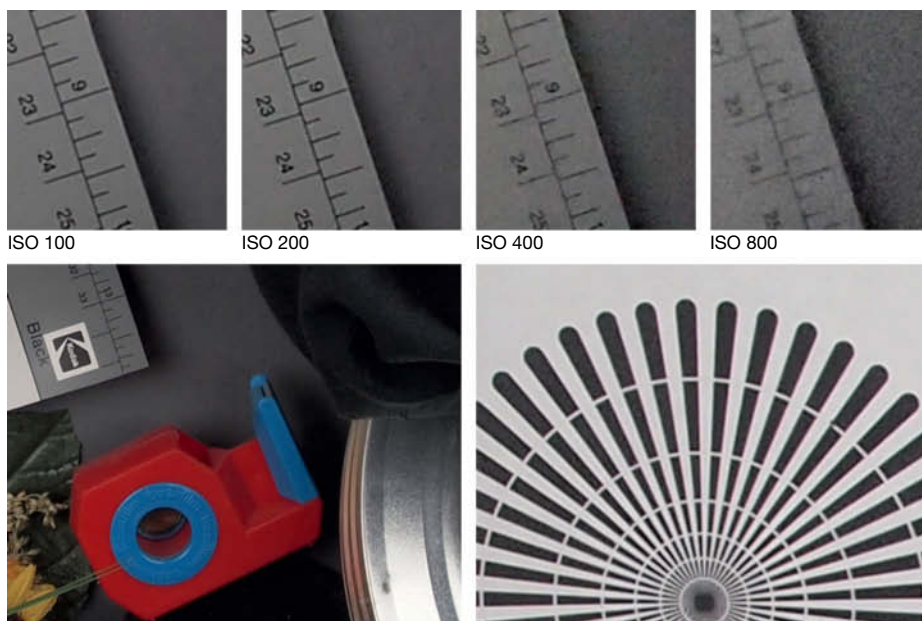
No command dial. Built-in speaker located under user's thumb in normal use. Low-resolution main menu. AF unreliable in low light. Rudimentary self-timer. Built-in flash small and weak. Combined battery/memory card slot, card difficult to insert. No mains connector. Not SDXC-compatible. Maximum seven-minute video length. Tripod mount not aligned with the lens.

Test results: Contrast very good at ISO 100, dropping off toward ISO 800 and poor thereafter. Good signal-to-noise ratio and acceptable visual noise at ISO 800. Excellent, 93 percent center resolution at ISO 100 and only slight drop-off at ISO 400. Significant drop-off beyond ISO 400. Startup and shutter lag equivalent to compact camera levels.

Image quality: Tested using the M. ZUIKO Digital ED 14-42mm f/3.5-5.6 lens. Relatively neutral, slightly dull colors in daylight. Our orange sticker appears salmon-colored. Good,

balanced, slightly artificial-looking sharpness, but good detail for a 12-megapixel sensor. Balanced exposure. More than adequate noise compensation at ISO 800 in spite of the small sensor. Clean, well-defined reproduction at ISO 100, with slight grain and detail drop-off at ISO 200. Grainy artifacts in gray objects at ISO 400. Detail, definition and sharpness reduced at ISO 800. Images less sharp and with widespread purple noise artifacts above ISO 800. Fringing on the sieve, text and corner marks. Little or no moiré effects.

Good outdoor color rendition. Balanced exposure with adequate, slightly artificial-looking sharpness but good detail definition for a 12-megapixel sensor. Noise compensation good up to ISO 400, but with acute drop-off thereafter. Generally very few noise artifacts.





Sony SLT-A55V

Compact DSLR with fixed, semi-translucent mirror, 16-megapixel CMOS sensor and electronic viewfinder. Live view AF using dedicated focus sensors. 10fps continuous shooting and Full HD video.

Good: Compact, solid, easy-to-handle body with low viewfinder enclosure. Rubberized thumb pad and battery bulge. CMOS sensor with sensor shift image stabilizer. Prominent command dial, tilt/swivel three-inch monitor with 921,00-dot resolution. Semi-translucent mirror allows constant live view and fast, accurate AF via 15 focus areas and three dedicated cross sensors. Camera's construction makes it possible to shoot fast, quiet image sequences and Full HD video. High-resolution electronic viewfinder with artificial horizon feature. Clear menu structure with tabs, sub-tabs, and additional icon-controlled settings. Fast-reacting camera. White balance with fine-tuning and Kelvin settings plus white balance bracketing sequences. Built-in flash

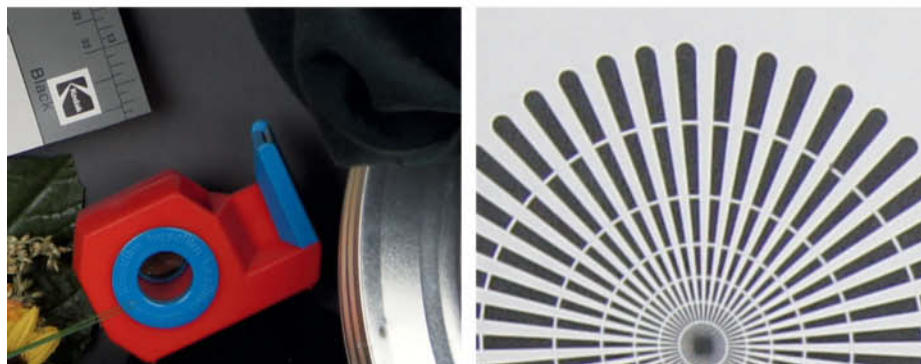
is adequate and has short charge time. Compatible with Memory Stick and SDHC/SDXC memory cards. Remaining battery power displayed as % value. Reliable built-in GPS module. Handheld sweep panoramas and 30fps AVCHD video.

Not so good: Four-way controller too small and too deeply recessed. Monitor hinge badly positioned, viewfinder colors over-saturated. No program shift. Combined battery/memory card slot. No video OUT connector. Manufacturer warns of over-heating when shooting long image-stabilized video clips.

Test results: Best contrast at ISO 100 and ISO 800, not as good at ISO 400. Good signal-to-noise ratio up to ISO 800 and low visual noise up to ISO 1600 (less than with many APS-C cameras). Test lens delivered 89 percent resolution at ISO 100, dropping off slowly toward ISO 1600. Resolution 54 percent at ISO 12800. Little shutter lag with the kit lens.

Image quality: Tested with a Sony 18-55mm f/3.5-5.6 DT AF lens. Faithful color rendition in daylight with slight tendency to yellow. Our orange sticker appears genuinely orange. Center sharpness very good at small apertures, poor at wide apertures. Very good center detail. Exposure often too bright. Images shot at ISO 100 and ISO 200 clean and sharp. Good solid colors, some fringing at ISO 400, but with good detail. Brightness noise and loss of detail at ISO 800. Images start to look dull at ISO 1600. Thereafter many artifacts and a loss of sharpness. Generally little moiré and obvious fringes only on the test-shot sieve.

Outdoor color rendition good with slight tendency to yellow. Exposure slightly inconsistent. Middle focal lengths only passably sharp, even stopped down. Kit lens only of medium quality. Normal image noise up to ISO 400, worse thereafter for detailed subjects. Fringing present but not critical.



Entry-level DSLR

The Olympus body costs around US\$450, which is around US\$150 less than the list price of the new Nikon D3100. The Nikon is more compact than its predecessor, the D3000, and thanks to its new 14-megapixel CMOS sensor has the live view, Full HD video mode and HDMI connector that were missing in the earlier camera. The camera's ISO settings range from 100 to 3200, and photos shot using default exposure settings at ISO 800 or 1600 are of acceptable quality.

The Nikon's compact size, full feature set and easy handling make it a great beginner's DSLR. The direct settings that can be made using the **info** button are a useful exposure aid, and complete beginners can use Guide Mode to help them get satisfactory. The Nikon's autofocus system is not as fast as the one built into Canon's entry-level cameras, and the Nikon kit lens delivers disappointing results whether wide open or stopped down, even outside of the more critical wide-angle range.

Prosumer Quality from Canon ...

The Canon EOS 60D is less of an update and more of a boiled-down successor to the EOS 50D. The camera's body is smaller and, due to its plastic body, lighter than its predecessor. The new model has an 18-megapixel sensor that records Full HD video on SD cards. It has also inherited the high-resolution 3:2 monitor used in the Rebel 2Ti/EOS 550D model, and has also been given tilt/swivel functional-

ity. The camera has no X sync socket but is capable of controlling slave flash units wirelessly. The shutter can be released via infrared remote. The upper Auto ISO limit is now user-controllable and the camera is capable of converting RAW files to JPEG in-camera. The user interface has been updated too, and the familiar Canon joystick is no longer part of the package. Continuous shooting mode is slightly slower than that of the 50D and the camera's memory buffer is also slightly smaller.

The 60D tested well, with its typical Canon user interface, scroll-free main menu and **Q** button for accessing the Quick Control screen. In general, the buttons are too flat and are a little difficult to operate by feel alone. The quick control dial is overloaded with 15 different functions, and has been equipped with irritating end stops and a lock function. The multi-controller is rather spongy and imprecise. Autofocus reacts very quickly when used with ultrasonic (USM) lenses, but the contrast detection AF in live view and video modes is slow and juddery. The kit lens is quite loud when it is focusing and doesn't produce satisfactory sharpness. The camera is equipped with an internal database for correcting color fringing and vignetting effects for a wide range of Canon lenses.

... and from Nikon

Nikon is positioning the D7000 optically and technically between the D90 and the D300s. The camera's body is made partly of magnesium and is water and dust resistant. The 16-

megapixel CMOS sensor shoots Full HD video with constant autofocus, although the kit lens can hardly keep up and constantly moves in and out in its search for the right setting. The video button is built into the new and very useful live view switch. Photo autofocus is handled by a 39-point system, while the light metering system is equipped with a 2,016-pixel RGB sensor of its own. The viewfinder covers 100 percent of the frame and the three-inch monitor has high (920,000-dot) resolution. Unlike with the Canon, the Nikon's monitor is not tiltable. The camera has two configurable SD card slots, the 6fps continuous shooting mode can be slowed down if necessary, and "Quiet" mode allows the photographer to keep the mirror raised for as long as the shutter-button is held down during single exposures. The D7000 has HDMI, stereo microphone and GPS connectors. Unfortunately, the Nikon battery and the camera's battery compartment are equipped with chips that prevent you from using third-party batteries.

The D7000 is extremely configurable, and has a complex system of menus that requires you to click through up to six different screens to reach some settings. You can operate some regularly-used functions and customize button settings via the My Menu screen. There are also numerous shortcuts available via the buttons on the camera back. The mode dial is really two dials in one, with the lower of the two being used to set the drive mode.

The 18-105mm kit lens produced sharp images across the board at medium or small apertures. Matrix metering was slightly inconsistent in outdoor situations and tended

Interchangeable-lens Cameras – Test Results. Part 3

	Signal-to-noise ratio [S/Nx] 100 ISO better ▶	Signal-to-noise ratio [S/Nx] 400 ISO better ▶	Signal-to-noise ratio [S/Nx] 1600 ISO better ▶	Signal-to-noise ratio [S/Nx] 3200 ISO better ▶	Signal-to-noise ratio [S/Nx] 6400 ISO better ▶	Signal-to-noise ratio [S/Nx] 12800 ISO better ▶
Canon EOS 60D with EF 50mm f/2.5 Compact Macro	68.0	47.0	35.0	27.0	20.0	16.0
Nikon D3100 with AF Micro-Nikkor 60mm f/2.8D	64.0	46.0	34.0	32.0	22.0	13.0
Nikon D7000 with AF Micro-Nikkor 60mm f/2.8D	82.0	53.0	35.0	33.0	25.0	17.0
Olympus PEN E-PL1 with M. Zuiko ED 14-42mm f3.5-5.6	56.0	44.0	35.0	25.0	–	–
Sony SLT A55V with Sony/Minolta AF 50mm f/1.4	54.0	40.0	37.0	31.0	28.0	24.0

Larger signal-to-noise ratio values indicate better image reproduction with less unwanted

Interchangeable-lens Cameras – Test Results, Part 4

	Visual noise OECF20 ISO 100 ◀ better	Visual noise OECF20 ISO 400 ◀ better	Visual noise OECF20 ISO 1600 ◀ better	Visual noise OECF20 ISO 3200 ◀ better	Visual noise OECF20 ISO 6400 ◀ better	Visual noise OECF20 ISO 12800 ◀ better	Startup time [s] ◀ better	Shutter lag [s] ¹ ◀ better
Canon EOS 60D with EF 50mm f/2.5 Compact Macro	0.7	0.9	1.5	2.3	4.1	7.4	0.4	0.28
Nikon D3100 with AF Micro-Nikkor 60mm f/2.8D	0.6	1.0	1.6	1.8	3.2	7.0	0.4	0.63
Nikon D7000 with AF Micro-Nikkor 60mm f/2.8D	0.5	0.7	1.4	1.7	2.4	4.5	0.4	0.54
Olympus PEN E-PL1 with M. Zuiko ED 14-42mm f3.5-5.6	0.9	1.4	2.7	3.9	–	–	2.1	0.90
Sony SLT A55V with Sony/Minolta AF 50mm f/1.4	0.7	1.1	1.7	2.3	3.5	5.7	1.0	0.35

¹ Measured with kit lens

"Visual noise" is a physiologically-based judgement of how "irritating" certain image noise artifacts appear to the viewer. The values are calculated based on the intensity, the frequency, and the color of the perceived noise artifacts. Values below 0.8 represent virtually noise-free images, values below 2 for low-noise reproduction, while values between 2 and 3 represent visible but acceptable noise levels. Values above 3 represent disruptive noise levels. Values of 5 and above represent extreme, unacceptable noise.

to overexpose. Noise characteristics were the best we tested for ISO values up to 1600, and are excellent for a 16-megapixel sensor. outdoor shots taken at up to ISO 800 were fine, and, depending on the subject, higher values also produced adequate results.

Shooting Video

With the exception of the Olympus, all of our test models shoot Full HD video. The large sensors built into all of the cameras promise high quality footage, but video autofocus is

still a problem, and none of our test candidates can be considered a real substitute for a purpose-built camcorder. Automatic metering is also somewhat hit-or-miss and performing smooth, quiet zooms with a manual zoom ring requires a lot of practice. For these rea-

The Test Cameras

Manufacturer and Model	Canon EOS 60D	Nikon D3100
Website	www.canon.com	www.nikon.com
Digitization		
Native resolutions (in pixels)	5184 × 3456, 3456 × 2304, 2592 × 1728, 1920 × 1280, 720 × 480 (3:2, with 4:3, 16:9, or 1:1 available for each)	4608 × 3072, 3456 × 2304, 2304 × 1536
Sensor type, effective MP / Size / Self-cleaning	CMOS, 18 / APS-C (22.3 × 14.9 mm) / ✓	CCD, 14 / APS-C (23.1 × 15.4 mm) / ✓
Image format(s) / Compression rates / Video format	RAW, JPEG, RAW+JPEG / 2 / MPEG-4 H.264	RAW, JPEG, RAW+JPEG / 3 / MPEG-4 H.264
Video: max. resolution [Pixel], length, fps	1920 × 1080, 29 min. 59 s or 4 GB, 30	1920 × 1080, 10 min., 24
Memory card type / file size ³	SDHC/SDXC / 8.1 MB	SDHC/SDXC / 7.3 MB
Features		
Crop factor (35mm equiv.) / Bayonet	approx. 1.6x / Canon EF, EF-S	approx. 1.5x / Nikon F (AF)
ISO settings	auto (100, with selectable upper limit) 100-6400, (12800) in 1/3 or 1/1 increments	auto (100, with selectable upper limit), 100-3200 (6400, 12800) in 1/1 increments
Shutter speeds [s] / Default flash sync [s]	(bulb) 30-1/8000 / 1/250	bulb, 30-1/4000 / 1/200
Focusing / Image stabilizing	AF (one-shot, continuous, servo), MF / – (IS lenses)	AF (one-shot, continuous), MF / – (VR lenses)
AF focus areas / Focus assist lamp	9 cross sensors or 1 (9-point) / ✓ (series of flashes)	11 (1 cross sensor) or 1 (11-point) / ✓ (white)
Metering: Multi- / Center-weighted / Spot	✓ (63 zones) / ✓ / ✓	✓ (420 zones) / ✓ / ✓
Programmed auto / Scene modes / Custom Presets	✓ (with shift) / 6 / ✓	✓ (with shift) / 7 + guide mode / –
Exposure: Aperture priority / Shutter priority / Manual	✓ / ✓ / ✓	✓ / ✓ / ✓
Exposure compensation [EV] / Depth-of-field preview	±5 EV in 1/3 or 1/2 increments / ✓	±5 EV in 1/3 increments / –
Bracketing: Exposure / WB / Focus / Interval timer / Sound	✓ / ✓ / – / – / ✓ (16-bit, mono ⁸ , 48 kHz)	– / – / – / – / ✓ (16-bit, mono, 24 kHz)
Self-timer / Continuous shooting speed (JPEG)	10 or 2 sec. / 5.3 fps, 58 shots	10 or 2 sec. / 3 fps
White Balance: Auto + Man. / Presets / Fine-tuning	✓ / 6 / ✓ (plus Kelvin settings)	✓ / 6 / ✓
Sharpness, Contrast, Saturation adjustable / Color spaces	✓ (with fine-tuning, 3 memories) / sRGB, Adobe RGB	✓ (with fine-tuning) / sRGB, Adobe RGB
Viewfinder: Type / Magnification / Coverage	pentaprism / 0.95x / 96%	pentaprism / 0.8x / 95%
Monitor: Diagonal / Resolution [dots] / No. of brightness settings	3-inch (tilt and swivel) / 1,040,000 / 7	3-inch / 230,000 / 7
Live View / With AF using sensor / Dedicated sensors	✓ / ✓ (with face detection) / ✓	✓ (30 sec.-5 min.) / ✓ / –
Body material / Control panel / Auto monitor rotations	aluminium alloy and plastic / ✓ (with orange lamp) / –	plastic / – / ✓
4-way selector / Multi selector / Command dials	✓ (+ SET button) / 1 (lockable) / 2	✓ (+ OK button) / 1 / 1
Flash guide number (ISO 100) / Charge time / Connector	13 / 2.9 sec. / ✓ (TTL hot shoe)	13 / 3.3 sec. / ✓ (TTL hot shoe)
Playback		
Multiple [# of images] / Zoom / Histogram	9 or 4 / ✓ (up to 10x) / ✓ (with RGB display, also during shooting)	72, 9 or 4 or calendar / ✓ / ✓
Power / Connectors / Dimensions		
Power source	power adapter (proprietary), Lilon rechargeable battery	power adapter (with dummy battery), Lilon rechargeable battery
Interfaces / A/V out / HDMI / Remote release	USB 2.0 / ✓ (+ stereo microphone IN) / ✓ (type C) / ✓ (infrared or cable)	USB 2.0, GPS IN / ✓ / ✓ (type C) / ✓ (cable)
Dimensions (W/H/D) / approx. weight ⁶ Body, with test lens	145 mm × 106 mm × 79 mm / 770 g, 1220 g	124 mm × 96 mm × 75 mm / 505 g, 770 g
What's in the Box		
Manual / User guide	Manual	quick start guide, manual
Included accessories	Lilon battery LP-E6 (7.2 V, 1800 mAh, 13 Wh), charger, body cap, carrying strap, USB cable, AV cable, kit lens (if applicable) without sunshade	Lilon-Akku EN-EL14 (7.4 V, 1030 mAh, 7.7 Wh), charger, body cap, viewfinder cap, hot shoe cover, carrying strap, USB cable, kit lens (if applicable)
Optional accessories	memory cards, mains power adapter, IR and cable remote, HDMI cable, sunshade(s) for lens(es), ever-ready case, battery grip, stereo microphone, Data Security kit, other dedicated EOS accessories	memory cards, mains power adapter, cable remote release, GPS receiver, AV cable, HDMI cable, ever-ready case, other dedicated Nikon accessories
Software		
Standalone Software (platform)	ZoomBrowser EX 6.6 (Win), ImageBrowser EX 6.6 (Mac), EOS Utility 2.9, Digital Photo Professional 3.9, PhotoStitch 3.1/3.2, Picture Style Editor 1.8 (Win/Mac)	Nikon ViewNX 2 (Win/Mac)
Ratings		
Test images ¹ (c't test image shot in daylight)	shot using Canon EF-S 18-135mm f/3.5–5.6 IS lens	shot using Nikkor 18-55mm f/3.5-5.6G VR AF-S DX
Color rendition / Exposure	⊕⊕ / ⊕	⊕ / ○
Sharpness / Detail rendition	⊕ / ⊕	⊕ / ○
Image noise / Other artifacts ²	⊕ / ⊕	⊕ / ⊕
Ease of Use ⁴ / Printed manual	⊕ / ⊕	⊕⊕ / ⊕
Feature set ^{4,5} / Included accessories ⁴	⊕⊕ / ○	⊕ / ○
RRP: Body / With test lens (approx. in US\$)	999 / 1299	599 / 649
¹ judged by eye on a calibrated monitor		
² artifacts, noise, moirés, color fringing		
³ average, using largest native image size and best JPEG quality		
⁴ relative to similar class of camera		
⁵ nur fototechnische Ausstattung		
⊕⊕ excellent ⊕ good ○ satisfactory ⊖ poor ⊖⊖ inadequate ✓ included – not included n/a not applicable		

sons, DSLR video usage is still limited to short clips with as few pans and zooms as possible.

The Canon and the D7000 both shot sharp video footage using the kit lens, while the D3100 and the Olympus produced lower quality results with only average sharpness. The Sony's

design makes it the most likely to produce consistent video autofocus, but the kit lens isn't of high enough quality to do justice to the camera's sophisticated electronics. Additionally, the sensor shift image stabilization system produces constant background noise that reduces the

quality of the camera's already mediocre video sound. The Olympus also produces indifferent sound. The Canon and the D3100 produced adequate sound, but the D7000 was far and away the best of the bunch in this respect, even using the built-in microphone. (pen)

Nikon D7000	Olympus PEN E-PL1	Sony SLT-A55V
www.nikon.com	www.olympus.com	www.sony.com
4928 × 3264, 3696 × 2448, 2464 × 1632	4032 × 3024, 2560 × 1920, 1280 × 960 (4:3, with 3:2, 16:9 and 6:6 available for each)	4912 × 3264, 4912 × 2760 (16:9), 3568 × 2368, 3568 × 2000 (16:9), 2448 × 1624, 2448 × 1376 (16:9)
CMOS, 16 / APS-C (23.6 × 15.6 mm) / ✓	Live MOS, 12.2 / Four Thirds (17.3 × 13.0 mm) / ✓	CMOS, 16 / APS-C (23.5 × 15.6 mm) / ✓
RAW, JPEG, RAW+JPEG / 3 / MPEG-4 H.264	RAW, JPEG, RAW+JPEG / 2 (12 megapixel only) / MJPEG	RAW, JPEG, RAW+JPEG / 2 / AVCHD or MPEG-4 AVI
1920 × 1080, 20 min., 24	HD 720p, 2 GB or 7 min., 30	1920 × 1080, 29 min. or 2 GB, 25 or 30
2 × SDHC/SDXC / 7.2 MB	SD/SDHC / 5.8 MB	SDHC/SDXC + Memory Stick Duo (single slot) / 6.9 MB
approx. 1.5x / Nikon F (AF)	approx. 2x / Micro Four Thirds	approx. 1.5x / Sony alpha, Minolta AF
auto (100, with selectable upper limit), 100-6400 (25600) in 1/3 or 1/2 increments	auto (200, with selectable upper limit), 100-3200 in 1/3 or 1/1 increments	auto (100-1600), 100-12800 (25600) in 1/1 increments
bulb, 30-1/8000 / 1/250	bulb, 60-1/2000 / 1/160	bulb, 30-1/4000 / 1/160
AF (one-shot, continuous, tracking), MF / – (VR lenses)	AF (one-shot, continuous, tracking), MF / ✓ (sensor shift)	AF (one-shot, continuous, tracking, Eye-Start), MF / ✓ (sensor shift)
39 (9 cross sensors), 11 or 1 (39- or 11-point) or using just central area (21, 11 or 9-point) / ✓ (white)	25 (using face detection), 11 or 1 (11-point) / –	15 (3 cross sensors) or 1 (15-point) / ✓ (series of flashes)
✓ (2,016 zones) / ✓ / ✓	✓ (324 zones) / ✓ / ✓	✓ (40 zones) / ✓ / ✓
✓ (with shift) / 19 / ✓ (2 memories)	✓ (with shift) / 19 / ✓ (2 memories)	✓ / 8 / –
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
±5 EV in 1/3 or 1/2 increments / ✓	±3 EV in 1/3, 1/2 or 1/1 increments / ✓	±2 EV in 1/3 increments / ✓
✓ / ✓ / – / ✓ / ✓ (16-bit, mono ⁸ , 48 kHz)	✓ / ✓ / – / – / ✓ (16-bit, mono ⁸ , 48 kHz)	✓ / ✓ / – / – / ✓ (16-bit, stereo, 48 kHz)
20, 10, 5 or 2 sec. (1-9 shots, delay 0.5-3 sec.) / 6 fps	10 or 2 sec. / 3 fps, approx. 12 shots	10 or 2 sec. or Smile / 10 fps, approx. 45
2 / 6 / ✓ (plus Kelvin settings)	✓ / 8 / ✓ (plus Kelvin settings)	✓ / 6 / ✓ (plus Kelvin settings)
✓ (with fine-tuning) / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB
pentaprism / 0.94x / 100%	– (optional electronic or optica viewfinder) / – / –	electronic, (1,152,000 pixels) / 1.1x / 100 %
3-inch (with cover) / 921,000 / 7	2.7-inch / 230,000 / 14	3-inch (tilt/swivel) / 921,600 / auto or 5
✓ (5-30 min.) / ✓ / –	✓ / ✓ (with face detection) / – ⁷	✓ / – / ✓ (semi-translucent mirror)
Magnesium / ✓ (with green lamp) / –	metal and plastic / – / –	plastic / – / –
✓ (+ OK button) / 2 / 2	✓ (5 buttons) / 1 / –	✓ (+ AF button) / 1 / 1
12 / 3.9 sec. / ✓ (TTL hot shoe)	7 / 3.8 sec. / ✓ (TTL hot shoe)	10 / 3.3 sec. / ✓ (TTL hot shoe)
72, 9 or 4, or calendar / ✓ / ✓ (with RGB display)	100, 25, 9 or 4, or calendar / ✓ (up to 14x) / ✓	12 or 6 / ✓ (up to 11.8x) / ✓ (with RGB display)
Power adapter (with dummy battery), Lilon rechargeable battery	Lilon rechargeable battery	Power supply (proprietary), Lilon rechargeable battery
USB 2.0, GPS IN / ✓ (+ stereo microphone IN) / ✓ (type C) / ✓ (cable)	USB 2.0 / ✓ / ✓ (type C) / –	USB 2.0 / – (stereo microphone IN) / ✓ (type C) / ✓ (infrared or cable)
132 mm × 105 mm × 77 mm / 790 g, 1210 g	115 mm × 72 mm × 42 mm / 350 g, 480 g	124 mm × 92 mm × 85 mm / 505 g, 620 g
quick start guide, manual	Manual	Manual
Lilon battery EN-EL15 (7.0 V, 1900 mAh, 14 Wh), charger, body cap, viewfinder cap, hot shoe cover, carrying strap, USB cable, AV cable, kit lens(es) (if applicable)	Lilon battery PS-BLS1 (7.2 V, 1150 mAh, 7.8 Wh), charger, body cap carrying strap, USB and AV cables, kit lens (if applicable)	Lilon battery NP-FW50 (7.2 V, 1020 mAh, 7.3 Wh), charger, Body cap, viewfinder cap, carrying strap, USB cable, kit lens(es) (if applicable)
memory cards, mains power adapter, battery grip, cable remote release, GPS receiver, HDMI cable, ever-ready case, other dedicated Nikon accessories	memory cards, camera case, flash unit, interchangeable lenses, microphone adapter, HDMI cable, PEN lens adapter, underwater case and accessories	memory cards, mains adapter, infrared and cable remote release, HDMI cable, ever-ready case, accessory microphone, other dedicated Sony accessories
Nikon ViewNX 2 (Win/Mac)	Olympus ib (Win)	Picture Motion Browser 5.3 (Win), Image Data Converter SR 3.2, Image Data Lightbox SR 2.2 (Win/Mac)
shot using Nikkor 18-105mm f/3.5-5.6G ED VR AF-S DX	shot using M. ZUIKO Digital ED 14-42mm f/3.5-5.6	shot using Sony 18-55mm f/3.5-5.6 DT AF
⊕ ⊕ / ⊕	⊕ / ⊕	⊕ / ○
⊕ ⊕ / ⊕ ⊕	⊕ ⊕ / ⊕ ⊕	⊕ / ⊕ ⊕
⊕ ⊕ / ⊕	○ / ⊕	⊕ / ⊕
⊕ / ⊕	⊕ / ⊕	⊕ / ⊕
⊕ ⊕ / ○	⊕ / ○	⊕ / ○
1199 / 1499	430 / 450	749 / 849
⁶ measured	⁸ stereo available with accessory microphone	
⁷ no dedicated AF sensors, measurement using image sensor		



Alexander Altmann, Ralph Altmann

Creating Special Effects using **Optical Filters**

Digital image processing technology allows you to apply just about any effect you want to your images after shooting, so why take the trouble to use optical filters attached to your lens? This article describes some of the effects that can only be achieved using "real" filters and provides some tips on choosing and using optical filter systems.



While photo engineers do everything they can to convert every last ray of light reflected by a subject into usable tonal values, creative photographers follow a different route. They use filters to deliberately stop certain components of the light emanating from a subject from entering the lens, while allowing others to have a greater effect than normal. Unlike the software-based filters used in image processing programs, optical filters alter the light before it reaches the film or the camera's image sensor, producing effects that are different from those achieved by processing your images after shooting. A polarizer, which increases or decreases the effects of reflections in window glass depending on its physical orientation in the light path, is the best example of a filter that alters

incident light. Plain and graduated neutral density (ND) filters, too, can produce striking image effects. Digital technology has nevertheless helped many photographers to clear out their photo bags – red and orange filters for increasing the drama in black-and-white skies are now completely redundant, as are the various color filters that analog photographers used to compensate for changing lighting conditions. Digital white balance correction replaces colored filters without reducing the amount of incident light. Black-and-white conversions from color originals are quicker and easier on a computer than was ever possible in a darkroom, and can be undone, too. The use of prism, star or other effect filters has always been a matter of taste – such filters don't actually provide any addi-

tional optical information that cannot be produced digitally and have a large number of effective digital equivalents should you want to experiment with them.

Polarizers, plain and graduated neutral density filters and soft focus filters are still the most common and effective optical filters in everyday photographic use. Neutral density filters prevent overexposure and enable you to use longer shutter speeds, while graduated filters are great for accentuating the sky in landscape photos and polarizers are unbeatable for eliminating unwanted reflections. All of these effects can be used creatively, and it is only a small step from making a slight correction to the exposure of a sky to a full-blown, deliberate dramatization of the colors and shapes within a cloudscape.

Screw-in or Slot-in?

Filters are expensive, which can make owning multiple lenses with different sized filter threads a financially painful experience. Camera manufacturers appear to be uninterested in producing standard thread sizes. A few decades ago, Nikon equipped as many lenses as possible with standardized 52mm threads, but today produces lenses with 52, 55, 58, 62, 67, 72 and 77mm thread sizes. 77mm appears to have become something of a norm for wide-aperture zoom lenses.

If you don't want to buy separate filters for each of your lenses, you can use either threaded adapter rings or a slot-in filter system, depending on the type of filter you want to use. Graduated neutral density filters need to be moved up and down, making a slot-in system the only alternative. Screw-in polarizer, neutral density and soft focus filters are usually of better quality than their slot-in counterparts and often offer better value. Dense filters, like strong neutral density or infrared blocker filters, require a light-tight fit to work properly, so screw-in models are the only option.

Threaded Filters and Adapter Rings

A number of specialist manufacturers (B+W, Heliopan and Hoya) and camera manufacturers (Nikon, Canon or Sony) make screw-in filters and close-up lenses. Camera manufacturers don't offer as wide a range of sizes as the specialist makers do. High-end, coated glass filters not only produce superior optical results, but are also less sensitive to scratching and are easier to clean than plastic filters. Heliopan uses Schott glass; Japanese Tokina Co., the manufacturer of Hoya filters, is one of the largest producers of optical glass worldwide. Other companies rebrand third-party products, making it difficult for consumers to know whether the quality of their products will remain consistent from year to year. Don't buy "special offer" polarizers for US\$10 or less – it's simply not worth it.

You can save money, space and weight by buying screw-in filters to fit your largest lens and purchasing adapter rings to fit them to your smaller lenses. The price of

glass filters increases with diameter, but Heliopan and others offer high-quality black anodized brass adapter rings in various size pairings for between US\$15 and US\$50. Cheaper aluminum alternatives can be found in various places on the Internet, including eBay. An adapter's filter thread is usually larger than its lens thread, as using a filter that is smaller than the front element of your lens often causes unwanted vignetting effects. This is not necessarily true if you are using a full-frame lens on a camera with a small image sensor, as the image circle produced by the lens doesn't completely cover the sensor. If you do need to use a step-down adapter, Heliopan manufactures some of the best – for example, for attaching a 52mm filter to a 55mm lens thread.

It is also worth purchasing a lens cap to keep your glass filters protected while they are mounted, and a screw-in sunshade to match. The sunshades included with most lenses often don't fit onto accessory filters. Another way to save space in your bag is to screw filters of the same size together while you are not using them. There are also metal caps available to protect stacks of filters.

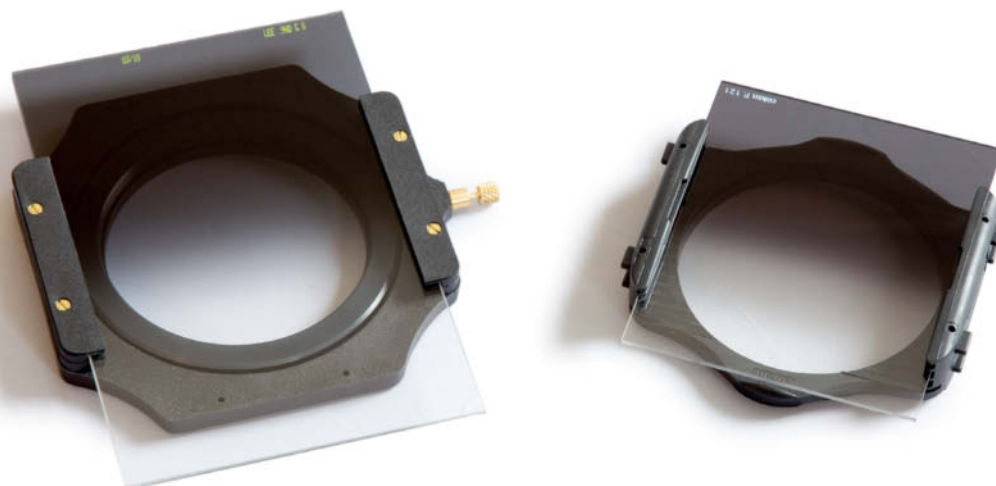
Slot-in Filter Systems

Slot-in filters are usually square and can be swapped out quickly and easily. The filter holders used with them can be rotated and the filters themselves can be moved within the slots in the holder, providing a very flexible approach to filter use. This type of system is, however, complex, and you have to attach the entire holder unit every time you want to use a single filter. Attaching a screw-in filter is much quicker. Filter holders also take up more space in your gear bag. As already mentioned, slot-in filters don't form a light-tight seal with the lens, so they are unsuitable for use with infrared blocker filters or strong neutral density filters. Most slot-in filters, like the well-known Cokin range, are made of plastic, and are more susceptible to scratches than their glass counterparts. They also have inferior optical qualities. Glass slot-in filters, manufactured by Lee or Singh-Ray, are often more expensive than equivalent screw-in filters, although the very highest-quality filters are usually only available in



A cheap, practical solution for lenses with different sized filter threads. Using 77mm two-stop neutral density and Soft-Pro filters combined with 52mm and 72mm adapter rings does away with the need to buy filters for each different sized lens you own.

The Lee filter holder system is shown on the left and the Cokin "P" System on the right. Both are equipped with 77mm adapter rings and have graduated neutral density filters mounted. The shallow Cokin adapter ring is hidden behind the filter holder.



Heliopan sells metal sunshades with the same sized thread at both ends, like the 77mm one shown here. This means you can attach the lens cap from your lens to the sunshade too. On the right is a filter protector cap made by B.I.G. attached to a stack of filters. The 77mm protector cap shown here costs about US\$20 and is available by mail order from www.fotobrenner.de.



screw-in form. The main advantage of slot-in systems is their ease of use for producing graduated effects. This is a killer feature for many landscape photographers, who always carry a holder and a filter or two with them.

The French Cokin system comes in four sizes. The older "A" system, for lenses with diameters of up to 62 mm, is enjoying something of a renaissance among digital compact users. The 42-82mm "P" system is the most popular, and offers flexibility and a wide range of filters at a reasonable price. The "Z-Pro" system is designed for use with lenses with 49-96mm threads and uses 100mm filters, while the "X-Pro" version accommodates 62-112mm lens threads and is too large for most photographic applications.

LEE filters, from England, are compatible with the Cokin "Z-Pro" system. Standard filters measure 100 × 100 mm, and graduated filters measure 100 × 150 mm. LEE filters are slightly thicker than their Cokin cousins and

are a tight fit in Cokin holders. Conversely, Cokin filters have a somewhat loose fit if used with LEE holders. The American Singh-Ray Corporation manufactures glass filters in the same sizes but does not produce its own holders.

A Cokin "P" holder and coupling ring set costs around US\$25 and a graduated neutral density filter to match costs a further US\$25. This is a great system for beginners and photographers who only occasionally use filters. However, some Cokin filters are

not especially color-neutral, and P-series graduated neutral density filters often produce a pronounced magenta cast. To avoid producing vignetting effects with wide-angle lenses, it is advisable to use the larger Z-Pro system or the more expensive, but more robust, LEE equivalent, which costs around US\$150 for a starter kit and US\$80 or more for a graduated filter. The color quality of LEE and Singh-Ray filters is generally better than that provided by Cokin, but comes at a price.

Slot-in Filter Systems

System	LEE (100 mm/4")	Cokin Z-Pro	Cokin P
URL	www.leefilters.com	www.cokin.com	www.cokin.com
For lens thread diameters	49-105 mm	49- 96 mm	48-82 mm
Filter dimensions	100 mm × 100 mm	100 mm × 100 mm	84 mm × 84 mm
Approximate prices (US\$)			
Holder	150	60	17
Coupling ring	45	30	8
Graduated neutral density filter	80	60	25

Polarizing Filters

Polarizer filters only transmit light that is polarized in a particular direction – see the explanation in the box below. The light from a conventional light bulb is non-polarized and contains rays with many different orientations, while linearly polarized light occurs in reflections from smooth, non-metal surfaces like water or glass. The light in a blue sky is largely polarized at 90 degrees to the sun, so when the sun is high in the sky, polarized light tends to come from the horizon. The more clouds there are in the sky, the less direct polarized light there will be, which is why polarizers have little effect on cloudy skies, but tend to give clear blue skies a seriously kitschy look. Polarizers can also reduce the contrast between the sky and the rest of a landscape shot, producing a similar effect to some graduated neutral density filters. A polarizer's positive effect continues below the horizon, helping to eliminate the blue haze that is often evident in landscapes shot in bright weather. This haze is caused by

the linearly polarized light from the sky, so adjusting the filter appropriately reduces haze while making greens and other colors cleaner and more saturated.

A linear polarizer has the same effect on non-polarized light as a neutral density filter, filtering out about half of the incident light. This means that appropriate filter settings can actually increase the relative strength of reflections in a scene. The light produced by a rainbow is largely polarized, and thus remains unfiltered if photographed through a polarizer, while the rest of the ambient light will be filtered to a degree equivalent to about one f-stop. The only problem with photographing rainbows through polarizers occurs if you want to capture an entire 90-degree section or more – in this case, parts of the arch will be filtered out no matter which way you orient your filter.

In the mountains, polarizers reduce haze and increase sharpness in the distance. Grass

and foliage appear more natural-looking due to the reduced reflections from their leaves. Polarizers also reduce unintentional overexposure due to reflections in car paintwork or windows. You can adjust any colors that might have been altered by the filter during post-processing, but washed out highlights and reflections are much more difficult to eliminate. Used at the correct angle, a polarizer can make the surface of a lake completely transparent, giving you an unhindered view to the bottom, or at least to the next layer of mud! Rotating the filter 90 degrees past this setting has the opposite effect, accentuating the reflections of the sky or the lakeshore in the water's surface.

So how do you recognize linearly polarized light? Simply hold up a polarizing filter in front of your eye and rotate it – if the ambient light visibly changes its character, it is polarized. If you perform this test using a circular polarizer, make sure you look through it



A deep blue summer sky with high-contrast clouds is usually the result of applying a polarizing filter. This is, in fact, an analog photo – the colors have been further intensified by the Fujichrome Velvia slide film used to take it.



On the left, you can see water, sky and foliage photographed without a polarizer, and on the right, the same scene photographed with a polarizer rotated for maximum effect. The blocked polarized light darkens the sky and reduces the reflections from the water. The leaves on the trees also reflect the sky and have a more intense color as a result. The histograms demonstrate clearly how the polarizer reduces contrast: the tonal distribution curve is flatter and displays fewer peaks of potential overexposure.

from the threaded side. The effect will barely be noticeable from the “wrong” direction.

Most modern polarizers are “circular”, which means that a circular polarizing layer is mounted behind the linear polarizing layer. This layer has no direct effect on the photo itself, but serves to give the camera’s autofocus and automatic exposure systems access to light that is polarized in as many directions as possible. The beam splitters that are part of the camera’s metering systems have a slightly polarizing effect too, so if the light that reaches them is already polarized, the di-

rection of its polarization would depend on the current filter setting, making metering errors unavoidable. The circular polarizer “depolarizes” some of the light, eliminating otherwise unpredictable metering results. Purely linear polarizers can, of course, be used with any DSLR that is set to manual metering mode.

Polarizers are still the most universally useful filters, even in the modern, digital age. If you keep a polarizer attached to your camera, remember to rotate it or remove it before you switch from landscape to portrait format

shooting or vice versa. Polarizers filter out up to two full f-stops of light if no polarized light is present in the scene you are photographing.

Polarizers can cause vignetting effects when used with wide-angle lenses, because their rotating frames make them thicker than most other filters. The exact aperture at which the effect sets in depends on the construction of the lens. B+W recommend using special “slim” polarizers (without front threads) for focal lengths of 28 mm and less. Other filters and lens caps cannot be used

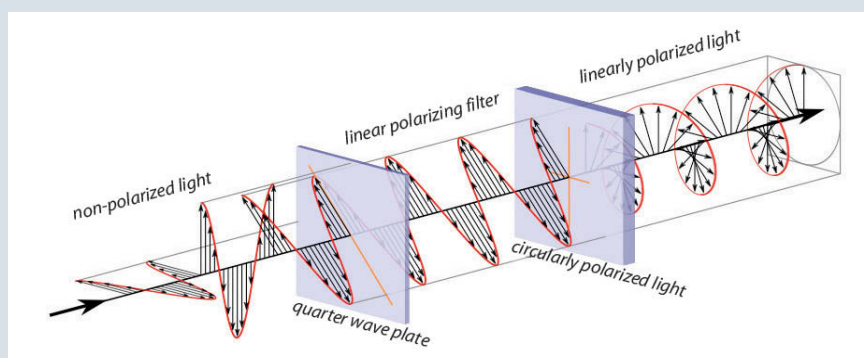
How Does Polarization Work?

Waves of electromagnetic radiation usually oscillate in arbitrary directions perpendicular to their direction of travel. Light waves are said to be linearly polarized if the waves oscillate within a particular plane. Polarization effects occur if light is reflected or when it travels through certain crystals or other media. Photographic polarizers are manufactured by stretching sheets of plastic to orientate the long-chain polymer molecules they are made of into parallel lines. The molecules then function like a grid that lets through only those light waves that are oscillating parallel to it. Light waves that oscillate perpendicular to the grid are absorbed. Polarizing filters are constructed so that they can be rotated to suit the direction of oscillation of the polarized light you are observing.

Light can be polarized linearly or circularly. Circularly polarized light occurs rarely in nature, but is often used for technical applications. It is produced by transmitting linearly

polarized light through an anisotropic “quarter wave plate” that retards one direction of the polarization of the source light by a quarter wavelength. This causes the direction of oscillation of the light waves

to rotate, producing circularly polarized light. Most modern polarizing filters have a built-in circular polarizing layer to ensure that the camera’s metering systems produce accurate results.



Commercially available polarizing filters consist of a linear polarizing filter for adjusting the optical effect of the image and an additional filter called a lambda quarter wave plate that causes the plane of polarization to rotate, helping the camera’s metering systems to deliver meaningful results



Shooting through windows. The photo on the left was taken without a polarizer. The one in the center was taken with a polarizer rotated for maximum cancellation, while for the one on the right, the filter was adjusted to allow the maximum amount of light through. The reflections are reduced or increased, depending on the filter's angle of rotation. Even the windows in the skyscraper produce stronger reflections in the right-hand shot.

with this type of polarizer. Unfortunately, the slip-on plastic caps that B+W includes with its slim polarizers seem to lose their sticking power over time.

Filters in which the glass is wider than the thread, or oversized filters used with step-down rings, can both help to reduce vignetting effects. Purists avoid using polarizers with ultra-wide-angle lenses with focal lengths of 20 mm or less. Here, the very large

angle of view causes the filter's effect to vary across the frame, with blue skies appearing almost black where they are at 90 degrees to the sun and bright blue in the corners of the frame. If you are aware of these types of effects and their causes, you can also use them creatively.

The differences in price between various brands of professional filters are due to the different types of manufacturing processes

involved. Multi-coated filters – labeled "MRC", "SH-PMC" or "S-HMC" by their manufacturers – reduce incidental reflections on both sides of the filter's glass and improve overall image quality, especially for lenses without sunshades or wide-angle lenses combined with large filters.

Usable polarizers start at around US\$25 for a 52mm, uncoated Hoya model. The most expensive filters are named after their inventor, Erwin Käsemann. These are made of plane parallel ground glass elements that are bonded with the filter's frame, protecting them from the effects of dust and humidity. Käsemann filters work perfectly under extreme weather conditions and ensure optimum image sharpness across the entire frame, even when used with super-telephoto lenses. Filters that combine Käsemann quality with multi-coating have only been available since 2002, when B+W introduced a cold-coating technique that prevents the polarizing layer from melting during manufacture. A B+W 77mm Käsemann Circular Polarizing Multi-Resistant Coating (MRC) Glass Filter costs around US\$180, while an equivalent Hoya "non-Käsemann" filter costs around US\$80.



Subjects that are lit by sunlight and blue sky look quite different when photographed using a polarizing filter. Blocking the polarized component of the light makes the colors in this image "cleaner" and more saturated.

Graduated Neutral Density Filters

Landscape photographers prefer to shoot very early or very late in the day, when the shallow angle of the sun makes the light “softer” and the shadows emphasize details. The problem with shooting at these times of day is that the contrast is often too great to expose both the landscape and the sky correctly. Either the landscape is correctly lit but the sky is too bright, or the sky and the clouds look great, but the details in the landscape are no longer visible. The solution is to dark-

en the sky during exposure – like reducing contrast in a print by dodging.

In this case, graduated neutral density (ND) filters perform the dodging role during shooting. ND filters are half gray and half transparent, with a gradual transition between the two areas. Positioning the gray portion of the filter to cover the sky equalizes contrast and produces well-exposed landscapes. Some photographers deliberately overdo this type of effect, for example to em-



Two graduated neutral density filters in use with a slot-in filter system. A tripod is essential in situations like this, and gives you a free hand for moving your filters and adjusting other camera settings.

Partially darkening the sky can produce dramatic visual effects. The graduated neutral density filter was positioned centrally for this shot.



Photo: Katja Gragert



A broad landscape with a dominant sky – a perfect situation for using a graduated neutral density filter.

phasize the color of a tropical sky above a beachfront hotel to a degree that doesn't occur in reality. Slot-in graduated filters can be easily moved up and down to the correct position within the frame. Screw-in graduated filters do exist, but limit the photographer to positioning the horizon in the middle of the frame.

You can position the graduation using the viewfinder or your camera's Live View mode. You can also use the depth-of-field preview button to help you judge the strength of the transition effect in your image. The smaller the aperture you use, the more abrupt the resulting transition will be. Wide-angles also produce "harder" transitions than telephoto lenses. The strongest graduated filters darken your image by three stops. If this is still not sufficient to achieve the effect you are looking for, simply com-

bine filters. Using multiple filters also allows you to extend the transition area or to produce two simultaneous transitions that run in opposite directions. You can also rotate your filter holder to make the transition run sideways.

Subjects with irregular horizons – and these are usually the most interesting ones – reveal the major weakness of graduated ND filters. For example, the top of a lighthouse in a photo shot using a graduated filter will end up in the dark if the transition is placed on the horizon. Such anomalies can be corrected to a degree during post-processing using tools like the Photoshop Dodge tool. Minilabs achieve similar effects with "digital masks" – transparent LEDs that adjust themselves to fit to the edges of selected objects during development – a technology that has not yet been applied directly in digital cameras.

Types of Graduated Neutral Density Filters

Graduated ND filters are available in a range that darkens images by a maximum of three full f-stops. LEE uses a logarithmic scale to indicate the strength of its filters, with 0.3 equivalent to one stop and 0.9 equivalent to three stops darker. LEE also offers "soft" and "hard" versions of its filters. Prices start at around US\$80 for 100 × 150 mm (4 × 6-inch) models. The "soft" transition is broader and less abrupt and helps to make the use of the filter less obvious in situations where the horizon isn't completely straight. Soft filters are also great for darkening the upper edge of images shot in early morning mist.

Singh-Ray is another manufacturer of high-quality filters. These are available by di-



The photo on the left was shot without a filter, while the one on the right was taken using a LEE three-stop soft graduated neutral density filter placed over the left half of the frame. This makes more of the detail outside the window visible while increasing the contrast between the subject and the wall – the photographer's original intention.



The photo on the left was taken without a filter. The one on the right was taken using a graduated neutral density filter, which kept the foreground bright while preventing loss of detail in the sky.

rect order or from www.bhphotovideo.com, and start at around US\$160 for a 100 × 150 mm (4 × 6") graduated ND filter. Cokin uses its own digit codes to denote its filter types: for example, 120 = between one and two stops of darkening with a hard transition, 121 = between two and three stops of darkening with a hard transition, while 121S = between two and three stops of darkening with a soft transition. All types are available for the "P" system, starting at US\$20, and for the Z-Pro system, starting at US\$40.

Graduated Filters vs. Digital Image Processing

The increasing popularity of digital image processing has called the use of graduated filters into question, with "Dynamic Range Increase" (DRI) processes supposedly taking their place. DRI should not be confused with the High Dynamic Range (HDR) process, which also merges multiple source images of differing brightness, but increases the overall dynamic range of an image to a degree that exceeds the conventional 8-bit or 16-bit color depth (with its 65,536 tonal values) used in the DRI process. DRI software merges the individual images in a bracketing sequence, but often has difficulty dealing with moving objects. It is also more time-consuming than using a filter.

As far as we know, landscape photographers still use graduated filters in preference to DRI techniques, and the rules for photo competitions often stipulate that the images submitted should be produced with a single press of a shutter button.

The main advantage of DRI is that the run of the transition (here called a "mask") can be adjusted to precisely fit the contours within the image – an ability not shared by conventional graduated filters. This difference makes DRI more practical for use with interior shots.

Contrast adjustments like those you can make using the Photoshop Shadows/Highlights tool or, even better, the contrast sliders in a RAW editor, are also not to be confused with DRI. These types of tools can only accentuate

detail that has already been captured by the image sensor, whereas graduated filters and DRI techniques make it possible to capture dynamic range that image sensors cannot otherwise encompass.

Graduated Neutral Density Filters

Manufacturer/System	Lee (100 mm)	Singh-Ray (100 mm)	Cokin Z-Pro	Cokin P
URL	www.leefilters.com	www.singh-ray.com	www.cokin.com	www.cokin.com
Lens diameter	49-105 mm	–	49-96 mm	48-82 mm
Material	plastic	plastic	plastic	plastic
Strength (in stops)	1, 2, 3	1, 2, 3	1–2, 3	1–2, 3
Available types	hard, soft	hard, soft, reverse ²	hard, soft	hard, soft, full ³
Approximate prices (US\$)				
Holder	150	– ¹	60	17
Adapter ring	40	– ¹	30	8
Graduated neutral density filter	80	160	40	20
¹ Fits LEE and Cokin Z-Pro ² Transition darkest in the center, lightens toward the top ³ Transition covers the entire filter				



In addition to the rectangular slot-in filter, you will also need a filter holder and an adapter to fit your lens. This picture shows a LEE holder and a 77mm adapter ring.

Neutral Density Filters

Neutral density filters – also known as ND or gray filters – reduce the amount of light entering the camera’s lens. They are most useful in situations where too much light can cause overexposure, such as when studio flash delivers too much flash power, or when you need to use a longer shutter speed for a video shot. In addition to technical applications, ND filters are also useful in creative contexts, particularly for artificially extending shutter speeds to produce motion blur.

Studio flash setups often produce too much light for shooting with wide apertures, especially in macro situations where the light source is very close to the subject. Flash power can usually only be regulated within a five-stop range, so a light gray ND filter can help you to achieve your desired aperture setting. If you are mixing flash with daylight, the daylight alone can be bright enough to prevent your camera from firing at the appropriate flash sync speed. Again, an ND filter provides the solution.

The range of shutter speeds available to movie and video cameras is more restricted than that found in stills cameras. Movie cameras usually work with shutter speeds that are double the frame rate – i.e., a camera will shoot with a shutter speed of 1/48 second for film that runs at 24 frames per second (fps). This ratio is also known as the “180-degree shutter rule”, due to the semi-circular rotating shutters used by movie cameras which are constantly either half open or half closed. If you want to give movements shot on video a “film look”, you will need to use a similar shutter speed. Human perception also seems to have its own “exposure time” of about 1/50 second, making moving images shot using similar shutter speeds more natural-looking. Individual video frames also need to display a certain degree of motion blur if they are to appear natural to the viewer. In countries where mains electricity alternates at 50 Hz, video shot using a 1/50s shutter speed

won’t produce flicker effects when viewed under artificial light.

The working aperture is critical to the depth of field in video footage, too, so the only other parameter you can alter to adjust exposure is ISO sensitivity. If you are shooting in daylight using a comparatively long shutter speed of 1/50s and a wide open aperture, you will quickly reach the lower limit of ISO sensitivity, which is where an ND filter comes into play. Keep two-stop and four-stop ND filters handy, as these can also be combined to neutralize extremely bright ambient light. If you do combine filters, always mount the stronger filter at the front, so as to minimize the reflections that occur between the surfaces of the two filters.

You will need to use even stronger ND filters to shoot in daylight using extended shutter speeds – a wonderful technique for revealing aspects of a scene that would otherwise remain hidden because they take place too slowly to be observed normally. For example, we can only register the movement of a snail because its position changes if we look away for a while. Using a long shutter speed to create motion blur allows us to create the impression of a “racing snail”. Incidentally, most car adverts are shot using slow-moving cars and long shutter speeds.

Ornamental fountains and waterfalls are classic examples of motion blur effects. The human eye doesn’t perceive moving water as being completely blurred, but shutter speeds



Deliberate motion blur created without using a filter. This interior was so dark that an aperture of f11 produced a shutter speed of 1/3 second. It nevertheless took several attempts to get the model’s movement and the blur just right.

Neutral Density (Gray) Filters						
Manufacturer	B+W	Heliopan	Hoya	Canon	Sony/Zeiss	Marumi
URL	www.schneiderkreuznach.com	www.heliopan.de/Heliopan-Filters.pdf	www.hoyafilter.com	www.canon.com	www.sony.com	www.marumi-international.com
Strength (in f-stops)	1-10 (also available in a slim version)	1-10	1-3	2-3	3 only	2-8
Lens diameters	46-77 mm	28-105 mm	39- 95 mm	52-72 mm	49-77 mm	40.5-82 mm
Approximate price for a 77mm, two-stop, multi-coated filter (US\$)	80	90	55	100 (in set with polarizer and UV)	100	70



In this shot, we used an ND filter to produce extreme motion blur in a slow-moving subject. The photo was taken at ISO 50 and f11 with the help of two-stop and four-stop ND filters used with a polarizer. The four-second shutter speed makes the cumbersome passenger ship look like a speedboat.

of just a couple of seconds can make it appear soft and romantic – an effect that many filter manufacturers use in their brochures. ND filters with strengths of six stops and more allow you to introduce motion blur into photos of slow-moving subjects, such as clouds, fluttering flags, tree branches, grass, people walking or moving cars and boats. Faster-moving subjects are no longer visible at shutter speeds of 30 seconds and more, which can help you to produce photos of

popular tourist attractions looking deserted, even at crowded times of day. To produce this type of effect, the shutter speed needs to be a multiple of the longest period of time that any of the moving objects in the frame stay in one position. Otherwise, you will end up with “ghosts” in your image. You can, of course, use ghosting effects deliberately, and the brighter an object is compared with the background, the more obvious it will be in the final image.

ND filters not only reduce the amount of light required to make an exposure, but also darken the viewfinder image and slow down autofocus. It should still be possible to focus using the viewfinder if you use filters with strengths of up to six stops, and contrast-based Live View focus is still usable even if you darken the image by up to 10 stops. At these light levels, triangulation-based autofocus systems will generally no longer work. If your viewfinder or Live View image is too



The tram in this image stopped for about half of the 30-second exposure time. The 10-stop ND filter we used allowed us to shoot at f8 in early evening light, producing this striking “ghost train” effect.



Photo: Katja Gragert

Katja Gragert calls this photo “From Eternity to Eternity”. She used a one-minute exposure time to portray herself as a semi-transparent figure. The image was shot at f16 using a 10-stop ND filter.

dark, you can always make your focus and exposure settings before you mount the filter and then adjust the shutter speed manually according to the filter's strength.

Most cameras have a maximum manual shutter speed of 30 seconds. The only way to achieve longer speeds is by using the B (“Bulb”) setting. This involves keeping the shutter button pressed for the entire expo-

sure time. We would like to see the old-fashioned analog T (“Timer”) mode introduced into DSLRs, whereby the first press of the shutter button opens the shutter and a second press closes it again. You can also use a remote release with shutter lock functionality or a remote release with its own built-in timer, such as the *Giga T Pro* by Hähnel Industries Ltd. (approximately US\$100).

Unlike analog film, digital image sensors produce increased noise at longer shutter speeds. Some DSLRs record a second shot, called a “dark frame”, with the shutter closed, after a long exposure and automatically subtract the noise patterns present in the dark frame from the image you have just recorded. However, noise is a random phenomenon, so it can be just as effective to record several exposures using identical settings and to remove the noise from the entire series later using a computer. This technique is only effective if absolutely no camera or subject movement takes place between shots. Slide and negative films do not produce or record noise artifacts, but do suffer from reciprocity failure (also known as the Schwarzschild Effect), which requires you to lengthen your shutter speed disproportionately to the reduction in the amount of incident light once you work beyond the intended range of a film's sensitivity.



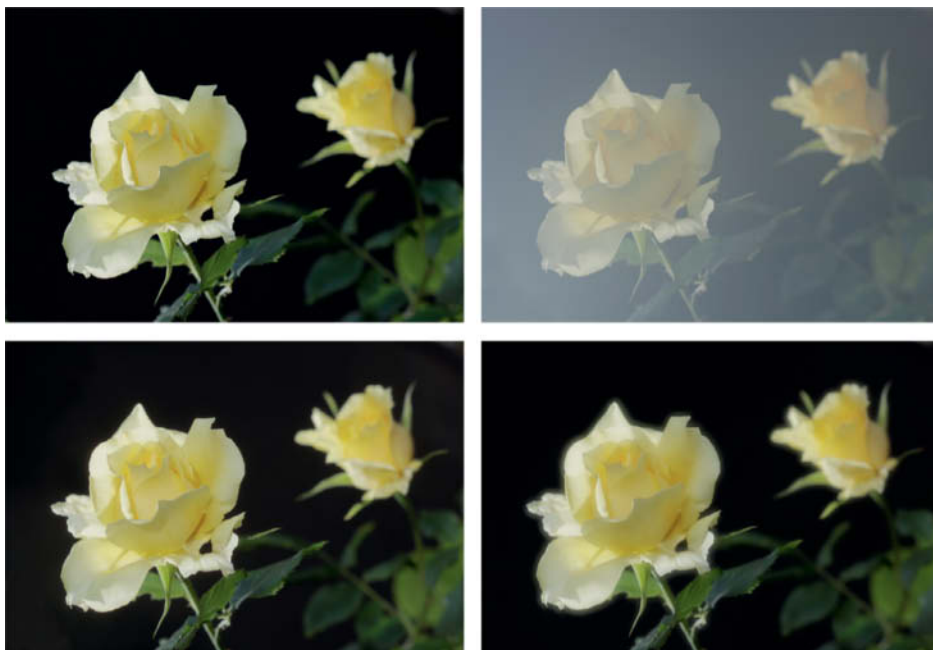
In this shot, we combined a graduated ND filter (to darken the sky) with a strong, pure ND filter to produce a two-second exposure time and a great deal of motion blur. The smaller image at top right shows the same scene photographed without filters.

Soft Focus Filters

Modern camera lenses generally produce sharp, high-contrast images with very little distortion. However, extreme sharpness is not always desirable in a photo, for example in portraits of models who don't have perfect skin. Soft focus filters are the perfect solution for making portraits and landscapes appear softer or more dream-like. Following the example of photographers like David Hamilton, many amateur photographers in the 1970s and 1980s wanted to produce their own "soft" images, and filter manufacturers responded with a range of different products. The range of soft focus filters available today is on the decline, due to recent increases in digital processing capabilities and changes in public taste.

The simplest soft focus effects are achieved using roughened glass, which produces the fog-like effect that gives these filters their name. Fog filters tend to overexpose highlights, but the effect is independent of the aperture you use. Fogged images are no longer in focus.

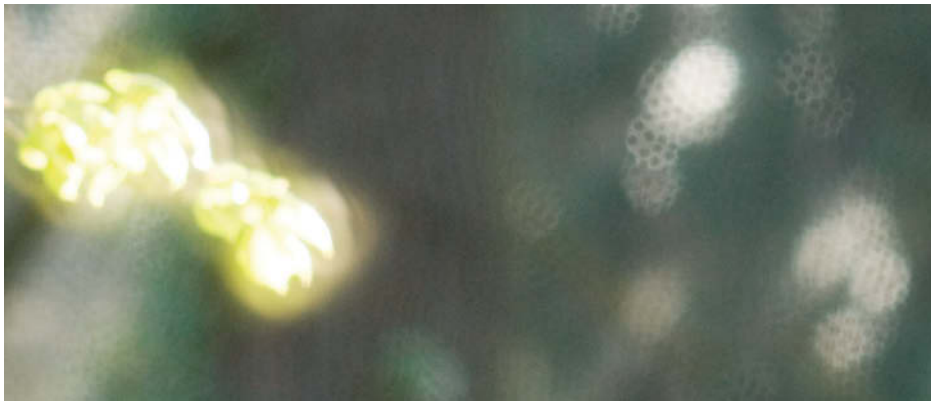
A Duto filter is constructed by engraving fine concentric circles into the filter's glass, which then function like mini-magnifiers, producing a second, out-of-focus image that



Comparing soft focus effects: the original image is shown at top left, and a fog filter effect is shown at top right. The image at bottom left was shot using a Duto filter and the image at bottom right using a Soft-Pro. All of these images were shot using a 105mm lens set to f5.6 and mounted on a camera with a 1.6x crop factor. The Duto has very little effect on the image at this aperture, whereas the Soft-Pro produces a clear fringe of light around the subject. The fog filter certainly lives up to its name.



The B+W Soft-Pro filter produces characteristic fringes around the backlit hair and leaves in this shot



An enlarged detail from the top right-hand corner of the image shown on the previous page. Here, you can see how the Soft-Pro filter reproduces its own surface texture around out-of-focus highlights.

is superimposed on the sharp original. The effect of a Duto filter depends on the distribution of brightness within the frame as well as on the aperture and focal length you are using. The narrower the aperture, the less effective the filter is. Strong background

highlights can make the rings themselves visible in the finished image. We found it difficult to predict the results produced by this filter.

Softar soft focus filters, which were invented by Zeiss, do not have any of these draw-

backs. They are made of plastic and consist of countless tiny drops of acrylic deposited randomly on a plane surface, which act as microlenses. Light passing through the filter between the microlenses forms the basic, in-focus image, while the microlenses form a second, more diffuse image that is superimposed on the original. Zeiss no longer produces Softar filters, but B+W has created the very similar Soft-Pro range of glass filters. Formerly available in two strengths, they can now only be purchased in the weaker variety, which is nevertheless strong enough for most applications. The 77mm Soft-Pro costs about US\$150 – about the same as a high-quality polarizer. Hoya sells the similar Softener filter, which costs about US\$70 for the 77mm version.

The effect produced by a Soft-Pro is virtually independent of the aperture you use, although it is generally more pleasing when used with wider apertures, as shallow depth of field harmonizes well with the filter's "filmy" effect. Soft focus filters benefit from bright incident light, whether from behind or as a backlight, as this produces the bright



Comparing the effects of different apertures: the two images on the left were shot without a filter, while the two on the right were shot using a Soft-Pro. The upper two images were shot at f2 and the lower two at f5.6. The wider aperture setting produces the most pleasing effect. All photos were shot using a 105mm lens and a full-frame DSLR.



A thin film of Vaseline applied to a cheap UV filter can produce a highly romantic effect. If you use your finger to spread the Vaseline sideways across the filter, you will produce vertical stripes in the resulting image, as shown in the photo on the right.

fringes that are characteristic of many soft focus effects.

You can easily construct your own variable soft focus filter using a cheap UV filter and a dab of Vaseline. Simply spread the Vaseline over the filter's surface with the tip of your finger. The effect this produces depends on how thickly you apply the Vaseline and the "pattern" you use to spread it. Nylon pantyhose are also a well-known way to produce home-made soft focus effects. Simply cut out piece of nylon and pull it tight over your lens, possibly using a rubber band to keep it in place. Black nylon reduces sharpness, while white nylon also reduces contrast. You can also use fishnet stockings, thin curtain material, or any other fabric for your experiments. There are no limits to the ways you can deliberately spoil the reproduction characteristics of your lens!

Software-based Soft Focus Effects

Theoretically, because they don't involve creating new pixels, most optical soft focus effects can be simulated using software. In practice, it is quite difficult to digitally duplicate the wonderful blooming and soft focus effects that some physical filters produce. The particular look of the defocused parts of an image depends on the way your lens is constructed and on the shape of its aperture blades. "Lens blur" algorithms have only recently begun to find their way into the filters built into the more common image processing programs. The well-known Gaussian Blur effect is not a real substitute for an optical soft focus filter, as it simply smudges edge contrast for a preset number of pixel rows. Superimposing a softer version of an image over the in-focus original produces more realistic-looking results. This is easy to achieve in Photoshop: simply copy the original image onto a new layer and apply a Gaussian Blur effect with a Radius of 15-40 and an Opacity value of 30-40%, and switch Blend Mode to Lighten. You can now experiment with different Radius and Saturation values. The results will look similar to Soft-pro or Softener effects, although skin tones will not look quite as soft and hair will not appear quite as radiant as when you use a "real" filter. You can produce more natural-looking results if you produce two separate images in the camera and merge them either using your image processing program or directly in the camera. In-camera merging only produces the desired effect if you use reduced exposure values and different focus settings for each source image.

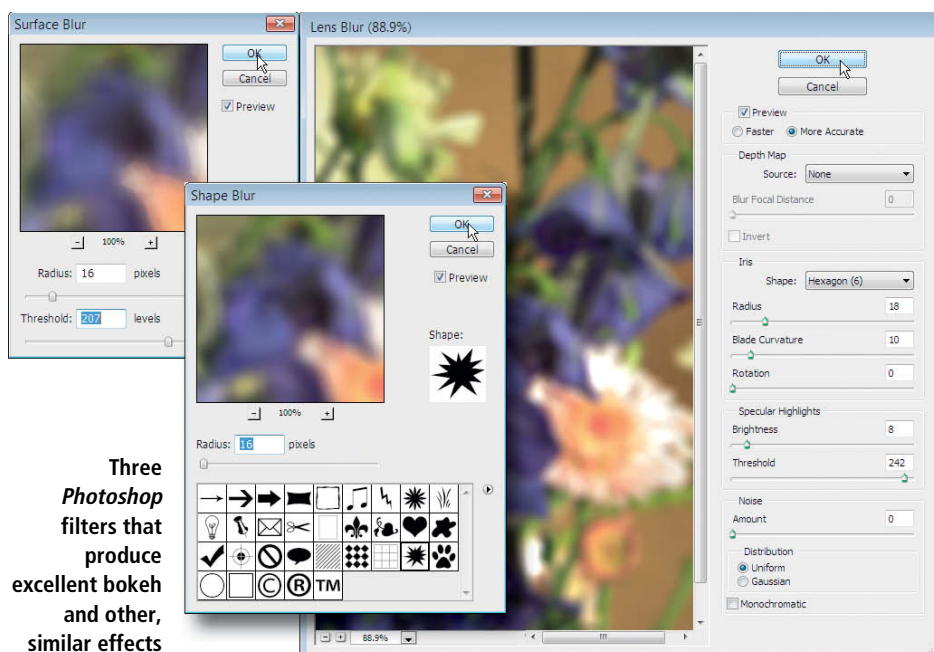
The Photoshop Lens Blur filter includes options for changing the shape of the aperture and the strength of specular highlights



The individual microlenses are easily recognizable on the surface of this Soft-Pro filter

(blooming effects). You can even influence the degree of bokeh you produce at user-defined subject distances using the Depth Map option. Depth maps can also be created using special cameras or, in the case of objects with easily recognizable outlines, using simple brush or selection tools.

The Photoshop Shape Blur and Surface Blur filters are also great for producing soft focus effects. The Shape Blur filter includes a library of preset shapes, and you can add your own funny or strange "apertures". However, "home-made" apertures are usually only visible at bright highlights.



Three Photoshop filters that produce excellent bokeh and other, similar effects

Basic Equipment and Conclusions

Optical filters still have their uses in the digital age, especially when it comes to directly manipulating light before it is subjected to the technical limitations of the image sensor that captures it. It is impossible to duplicate polarizing effects digitally, because the direction of polarization of light cannot be captured electronically.

We strongly advocate the use of Neutral Density (ND) filters for making long exposures or when you are shooting video. These allow you to lengthen your shutter speed virtually at will, making motion blur possible under most lighting conditions and making it possible to remove moving objects as if by magic. Many landscape photographers like to use graduat-

ed ND filters, but these require you to purchase a holder system. The use of soft focus and other effect filters is largely a matter of taste, as they produce additional atmosphere that is not present in the original scene or location light.

UV filters can still be used as lens protectors, but other color filters for creating color or black-and-white effects are redundant in this age of push-button digital image processing.

A basic filter setup for landscape photography consists of a polarizer, a six-stop or 10-stop ND filter and, optionally, one or two graduated ND filters and holders. A kit like this shouldn't cost more than about US\$120 if you are using standard-sized lens threads

and a mid-range polarizer. The same selection can cost up to US\$450 if you are using larger lenses and prefer using high-quality filters. Heliopan, B+W and Hoya are well-known filter manufacturers with good reputations, and each has its own specialties. Currently, only B+W offers multi-coated Käsemann polarizers. If you use filters regularly, it is worth investing in high-quality gear. Filters are literally the "front line" of your entire camera setup and play a significant role in determining the quality of your results. Remember, filters are not subject to obsolescence through technological progress, so any filters you buy now will most likely outlive several generations of cameras. (pen/jr) **ct**



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Quality is key



Photo: NASA

Rolf Hempel

Photographing the **ISS**

On a clear evening, as dusk turns to dark, you might just be able to see the ISS as it crosses the sky from west to east. Viewed with the naked eye, it appears as a small, bright spot in the sky but, with a little effort, it is fairly simple to shoot photos that clearly show the details of the world's first permanently manned space station.

The ISS (International Space Station) is the largest man-made object in space. Big enough to see with the naked eye, it is a prime subject for amateur and professional photographers alike. But is a DSLR with a telephoto lens up to the job? Or do we need to dust off the telescopes we used in our youth?

There are two slightly disappointing answers to these questions and one piece of good news. The major plus point is that the ISS is so bright that you can hardly miss it – it is brighter than any of the stars in the night sky, and only Venus, the Moon and the Sun are brighter. This means that you can see the ISS from just about anywhere, even in the middle of the city.

The problem with photographing the ISS is that it is never nearer than about 220 miles from Earth, even on a direct flyby. Even at its nearest, its 260-foot superstructure appears about as large as the Capitol Building in Washington viewed from Charleston in South Carolina! Or, put another way: if you were to line up 40 International Space Stations in a row, they would just about cover the breadth of the Moon seen from Earth. If you have ever tried to photograph the Moon using a standard lens, you will know just how much of a challenge it can be to take satisfying photos of heavenly bodies. The other major challenge the ISS presents photographers with is its speed, as a complete flyby lasts only about three minutes. In order to capture the ISS in any detail at all, you need to use an extremely powerful lens – but more about that in a moment. All this and the narrow field of view provided by long lenses make it quite tricky to capture the ISS shake-free on its way through the heavens.

Capturing a Light Trail

Taking a shot of the light trail left by the ISS as it passes over is a great way to practice for the “real thing” and is also a simple technique for capturing impressive photos of the night sky. Mount your camera – ideally a DSLR fitted with a medium wide-angle lens – on a tripod and point it at the portion of the sky the ISS is going to pass through (see the box below for more information on flight times). Use a cable release to begin your exposure as soon as the ISS appears and keep the shutter open for 60-120 seconds. The space station’s movement will then be captured as a continuous line across the sky. This type of image is most impressive if you capture foreground objects, such as trees or buildings, in your shot too. But make sure that any subsidiary objects aren’t too brightly lit, otherwise the light trail will appear too dark or the foreground too bright in the finished image. Se-

lect aperture and ISO settings to keep your foreground just on the right side of overexposed.

Capturing Details of the ISS

If you want to capture the ISS itself and not just a light trail, you will need an extremely long lens. Even a conventional 1000mm lens captures an image of the space station that is only about a quarter of a millimeter long, which is equivalent to about 40 pixels of a prosumer DSLR’s sensor. You will be able to recognize the ISS on an image like this, but it still isn’t anybody’s idea of a real high-resolution image. Ideally, your lens should have a focal length of at least 2000 mm, although longer is even better if you want to crop your results later.

However, these kinds of lenses are only available at the very top end of the market. The legendary Zeiss Mirotar 1000mm f/5.6 only covers the lowest end of the required range of focal lengths and cost more than US\$15,000 in the late 1980s. The longest super-telephoto lenses available today, such as the Canon EF f/5.6L 800mm IS USM (which retails for approximately US\$11,000), are only rarely available for hire and still don’t provide sufficient magnification for taking really detailed photos of the ISS.

A cheaper and more practical alternative is to attach your camera to a conventional astronomer’s telescope. The most important feature of a suitable telescope is the diameter of its front element, which needs to measure at least eight inches for our purposes. Any smaller, and you would have to use shutter speeds that are too long, increasing the risk



Photo: Rolf Hempel

A Schmidt-Cassegrain reflector telescope manufactured by Meade. The photo shows the 2080 LX3 model with a Nikon D80 attached. This model has an 8-inch aperture and 2000mm focal length.

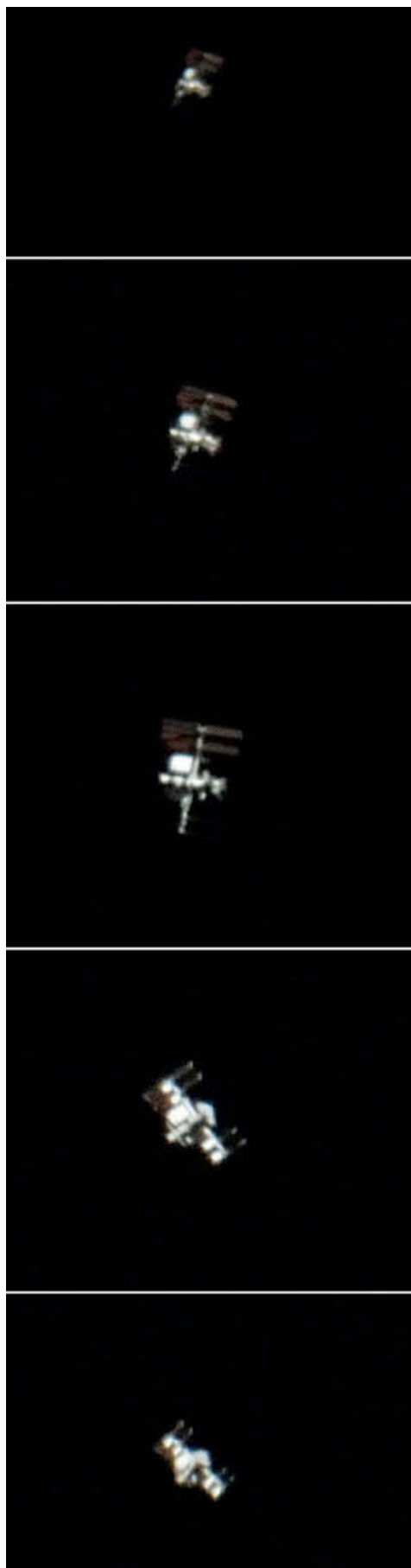
of producing shaky results. This size of traditional refractor telescope is very expensive, but equivalent reflecting telescopes with sufficient power can be bought pre-owned for US\$200-300. Check out your favorite astronomy website or the “For Sale” pages in any astronomy magazine for offers.

The simplest way to use a telescope to take photos is to attach a camera body in



Photo: Rolf Hempel

A light trail from the ISS, photographed passing over the Buchholz cemetery in Westerwald, Germany. The photo was taken at 04:29 CET on August 23rd 2009. The shutter speed was 120 seconds at ISO 200 using an 18mm f/5.6 lens.



ISS flyby on March 20th 2009 from 19:56:35 to 19:58:30 CET. These photos were taken using the Meade telescope illustrated on the previous page, with the camera set to 1/640 second at ISO 1000.

place of the eyepiece. T2 adapter rings are available for most telescopes, as are adapters that connect T2 mounts to most popular lens bayonets. This simple combination turns a telescope into a powerful telephoto lens. But care is needed, and you should be aware of the differences between conventional lenses and telescopes. The Schmidt-Cassegrain-type reflector telescopes popular with amateur astronomers everywhere usually have an aperture-to-focal-length ratio of 1:10, which means that their focal length is 10 times the diameter of the telescope's front element. This is equivalent to a photographic aperture setting of f10. A lens diameter of 20 cm therefore gives us a focal length of 2000 mm, which is the minimum required to shoot adequate quality images of the ISS. The ISS flyby shown on the left was photographed using a 23-year-old Schmidt-Cassegrain telescope. Other types of reflector telescopes have smaller focal ratios, which can, in the case of Newtonian telescopes, be as low as 1:5, making them unsuitable for taking photos of objects in space. However, you can artificially

extend the focal length of a telescope using a technique called "eyepiece projection". This involves inserting an eyepiece between the camera body and the telescope that magnifies the image produced by the telescope before it reaches the camera's sensor. Careful selection of the focal length of the eyepiece and the distance between it and the camera make it possible to construct a "lens" with just about any focal length. The disadvantage of this technique is that the greater the equivalent focal length, the larger the focal ratio will be. For focal ratios of 1:16 and more, the necessary shutter speeds will be too long to achieve satisfactory results.

An eyepiece projection attachment and T2 adapter should together cost about US\$75 and high-quality eyepieces are available for US\$120 or less, although most quality telescopes include an eyepiece anyway. You can purchase a new 8-inch Newtonian telescope for about US\$500, making this a great value way to start experimenting with super-telephoto astrophotography.

Photographing a Flyby

Once you have acquired all the necessary gear, you are sure to be itching for the ISS to make its next pass. The www.heavens-above.com website (see the box below) is a great source of ISS flight plan information. Avoid photographing passes below 50° of al-



An ISS enthusiast in action, using a Nikon D80 attached to a Schmidt-Cassegrain telescope

Photos: Rolf Hempel

Increasing focal length using the eyepiece projection technique. The length of the extension tube determines the magnification provided by the complete system.



titude, as the ISS is then not close enough to be seen properly.

The real work begins with focusing and takes place a few minutes before the ISS appears. Focus on a bright star or, if possible, the Moon. Live view functionality is a great focusing aid if your camera has it. If you should have trouble focusing, you can always take some test shots to help you select the best focus setting. The ideal ISO value varies from camera to camera, but I recommend that you select the highest possible value that doesn't produce excessive image noise. Manually selected shutter speeds of around 1/500 second are ideal, and everything happens so quickly once the ISS hoves into view that you won't have an opportunity

to change your setting anyway. If your shutter speed turns out to be less than ideal, you will simply have to adjust it and cross your fingers for your next attempt.

Things get really hectic once the ISS appears over the horizon, as even the fastest motor-driven telescope mount cannot keep up with its speedy journey across the sky. The only way to follow the space station is to release your tripod's locks and move your telescope as smoothly as you can by hand while following its path through the telescope's eyepiece or using your camera's Live View. You can then shoot as many photos as your camera's continuous mode and your memory card allow while the ISS is in view.

Photo: Ralf Vandenberg



An ATK-2C CCD camera attached to the eyepiece of Ralf Vandenberg's Newtonian telescope

How to find the ISS

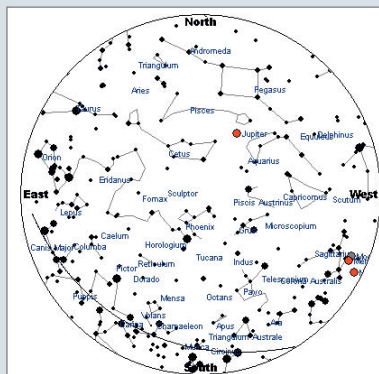
If you don't feel like spending every clear night scanning the sky for your quarry, the website at www.heavens-above.com publishes detailed ISS flight plans to help you with your search. The site's owner, Chris Peat, publishes all visible ISS passes two weeks in advance of the event. You begin by entering the geographic position you want to shoot from, and a simple click on the ISS link then produces a table detailing upcoming passes.

The start point, zenith and end point of a pass are listed for all routes that take place at above 10° of altitude. Below this altitude, the ISS is more than 750 miles away and cannot be satisfactorily photographed. The greater the value in the center Alt. column of the table, the closer the ISS is to the observation point. A value of 90 represents a direct overhead pass.

A click on the date entry in the table reveals a page with additional information about the selected pass, including a table of important points along the station's path and their related times and distances. Star maps give you additional information about the sky surrounding the pass and you can even zoom in to get a detailed view of any individual segments of the flight path. The Whole Sky Chart view helps if you are planning to take a photo of the ISS light trail.

Unfortunately, the ISS cannot be observed every day. For it to be visible, the sun has to be low enough at the observation point for the sky to be dark, but for the ISS to nevertheless remain illuminated. This is only usu-

ally the case in the late evening or early morning. During this window of opportunity, the Earth's rotation has to be such that the observation point is close enough to the space station's path to make it visible. All in all, this produces periods of about two and a half weeks during which the ISS is visible, followed by periods of 10 days or so during which it cannot be seen from Earth.



Pass Details
 Date: Tuesday, 07 December, 2010
 Satellite: ISS
 Observer's Location: Canberra (35.2830°S, 149.2170°E)
 Local Time: Australian Eastern Daylight Time (GMT + 11:00)
 Orbit: 346 x 356 km, 51.6° (Epoch 30 Nov)
 Sun altitude at time of maximum pass altitude: -7.8°

Event	Time	Altitude	Azimuth	Distance (km)
Rises above horizon	20:43:37	0°	214° (SW)	2,182
Reaches 10° altitude	20:46:09	10°	192° (SSW)	1,335
Maximum altitude	20:48:09	16°	149° (SSE)	1,024
Enters shadow	20:51:03	6°	96° (E)	1,601
Drops below 10° altitude	20:50:08	10°	107° (ESE)	1,326

ISS - Visible Passes

Search period start: 00:00 Tuesday, 30 November, 2010
 Search period end: 00:00 Friday, 10 December, 2010
 Observer's location: Canberra, 35.2830°S, 149.2170°E
 Local time zone: Australian Eastern Daylight Time (UTC + 11:00)
 Orbit: 346 x 356 km, 51.6° (Epoch Nov 29)

Click on the date to get a star chart and other pass details.

Date	Mag	Time	Starts Alt.	Az.	Max. altitude	Time	Alt.	Az.	Ends
1 Dec	-0.3	22:58:39	10	S	22:59:11	12	S	22:59:11	12 S
2 Dec	0.1	23:23:31	10	SSW	23:23:42	11	SSW	23:23:42	11 SSW
3 Dec	-0.9	22:14:48	10	S	22:16:32	14	SSE	22:16:38	14 SSE
4 Dec	-1.1	22:39:36	10	SSW	22:41:03	23	SSW	22:41:03	23 SSW
5 Dec	-1.1	21:30:38	10	S	21:32:31	15	SSE	21:33:55	15 ESE
5 Dec	-0.3	23:05:07	10	WSW	23:05:26	12	WSW	23:05:26	12 WSW
6 Dec	-2.9	21:55:20	10	SW	21:58:12	43	SE	21:58:15	43 SE
7 Dec	-1.2	20:46:08	10	SSW	20:48:12	16	SSE	20:50:07	16 ESE
7 Dec	-1.8	22:20:44	10	WSW	22:22:33	29	W	22:22:33	29 W
8 Dec	-3.0	21:10:44	10	SW	21:13:38	48	SE	21:15:19	21 ENE
9 Dec	-2.5	21:36:01	10	WSW	21:38:46	36	NW	21:39:35	29 N

Developed and maintained by Chris Peat, Heavens-Above GmbH. Hosted by . Please read the updated FAQ before sending e-mail. [Imprint.](#)

A www.heavens-above.com list of ISS passes for December 2010

Pass details and a star map for December 7th 2010 over Canberra, Australia

In spite of the short shutter speeds that you will be using, most of your shots will probably end up blurred, due either to the quickly changing atmospheric disturbance or the unreliable nature of shifting a tripod by hand. You are sure to produce a lot of images that land in the trash immediately and only a few will be good enough for further processing. But it is worth persevering, and you can often end up with a series of images like the one reproduced on page 94.

Tweaking Your Results

The less image noise your camera produces and the more powerful your telescope, the better your results will be. For even better results, try replacing your camera with a video camera module. At frame rates of 50 fps (frames per second) and more, you will almost certainly end up with more usable material at the end of a shoot, increasing the probability of getting a near-perfect shot enormously.

You can also use specialized software to merge several images into one to reduce noise and increase sharpness. *RegiStax* and *Giotto* are two excellent freeware programs designed to do just that, the former is included on this issue's free DVD.

Ralf Vandebergh from the Netherlands is one of the world's best-known ISS photographers. He has made fantastic shots of the ISS and the Discovery space shuttle – two of which can be seen here – using an ATK-2C CCD camera mounted on a relatively modest



The ISS photographed on August 27th 2009, showing the then new Japanese "Kibo" module to the left of the central cross

10-inch Newtonian telescope that he pans by hand. Vandebergh also uses an additional eyepiece to increase the effective focal length of his telescope from 1,200 mm to 4,000 mm. The Atik camera he uses is sensitive enough to allow shutter speeds of between 1/500 and 1/1000 second in spite of the effective focal ratio of 1:16.

Tobias Lindemann, Josef Huber and Dr. Klaus Nagel – three amateur astrophotographers – have developed an even more professional technique using the 31.5-inch/8000mm Nasmyth reflector telescope at



Photos: Ralf Vandebergh

The Discovery space shuttle on August 30th 2009 at a distance of 250 miles. The shuttle was just 37° above the horizon at the moment this shot was made.

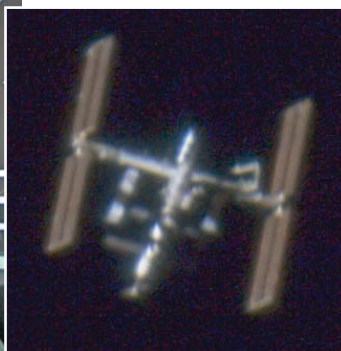
the Bavarian Public Observatory in Munich. Steering a telescope of this size manually is impossible anyway, so they adapted the telescope's built-in computer control systems to automatically follow the ISS on its path across the sky. They have achieved this using a two-stage plan. First, they use publicly available information on the projected flight path to calculate the route the ISS will be following. Then, because the narrow angle of view of such a large telescope makes blindly following even precisely calculated flight information risky, they mounted a tracking telescope fitted with a video camera to the side of the main telescope. If the actual path of the ISS begins to vary from the projected path, the team sends appropriate steering signals to the main telescope's control systems. The result of all this effort is a system that perfectly tracks the ISS while eliminating any risk of camera shake.

Of course, most amateur astronomers do not have access to such a large telescope, but the results perhaps nevertheless justify using similar control systems with your own telescope. Most telescope mounts are nowadays fitted with motor-driven adjustment systems that can be controlled using a computer via the standardized ASCOM interface, and it is relatively simple to fit a webcam to the eyepiece of a telescope.

But, as we have already shown, you can shoot impressive photos of the ISS using the simplest of methods. Now that building work on the station is almost complete, the time is ripe for recording the results of all that work. Some images printed here, as well as some additional material, are included at high resolution on this issue's free DVD. (jr) **ct**



The ISS experts in Munich, pictured with the computer-controlled reflector telescope at the Bavarian Public Observatory



The ISS photographed from the Bavarian Public Observatory Munich on August 1st 2007




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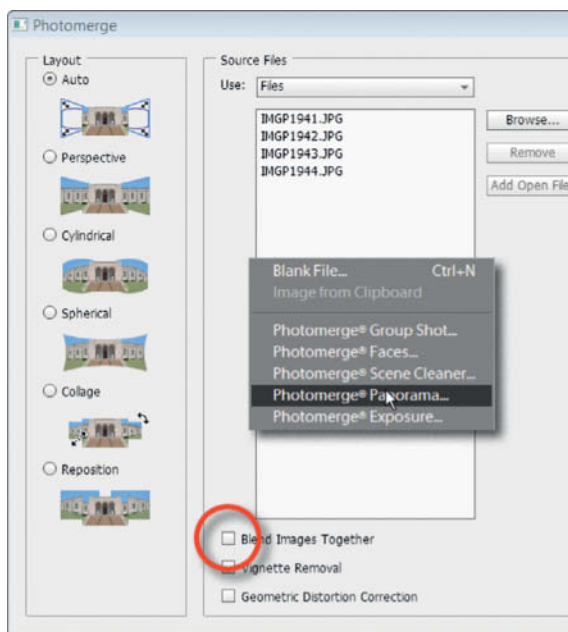


Ralph Altmann

Image Stacking

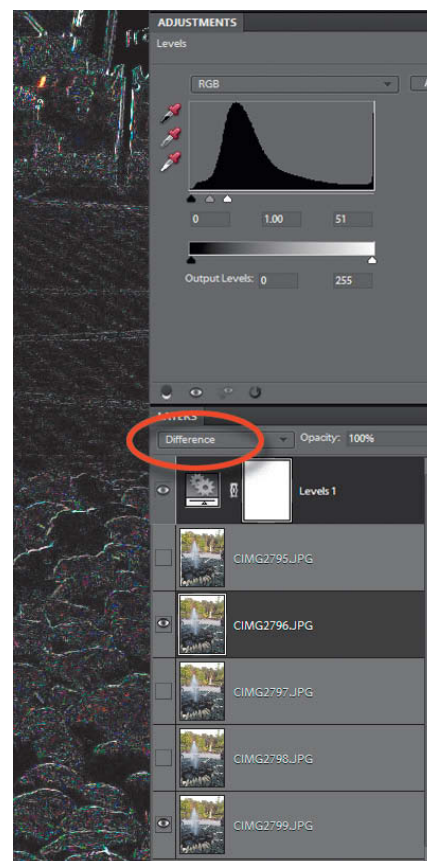
Some cameras are capable of merging multiple images to reduce image noise or to make a single high dynamic range (HDR) image. If you are prepared to do some tweaking on a computer, you too can use merging and stacking techniques to squeeze some extra quality and special effects out of your image data.





The Photoshop Elements Photomerge Panorama tool can be used to stack images into a perfectly aligned layer group. The Auto setting often produces better results than Reposition. Whichever you use, make sure that you uncheck the Blend Images Together option.

Automatic alignment doesn't always work perfectly, so check each layer of your stack. Switch the blending mode on the top layer to Difference before making any manual adjustments to layer alignment. You can check for any remaining alignment errors by adding a strongly brightened Levels adjustment layer to the entire layer stack.



The continuous shooting mode built into many cameras was originally intended to help the photographer capture the perfect moment. Sports photographers often shoot in continuous mode and simply select the best image from the resulting sequence. Exposure and white balance bracketing sequences allow you to produce sets of images with exposure and white balance parameters that are automatically varied by a preset increment. Again, the best image gets used while the others end up in the trash – which is actually a shame, as most images in a sequence contain useful image data. HDR images are the best example of how to use all of the images in a sequence to maximize your data yield.

Multishot techniques have been used for a while now to reduce noise and increase dynamic range for scanners. In this case, image alignment is taken care of on a hardware level, which is not true for cameras, even if you shoot using a tripod. The most important part of any multishot process is the initial alignment of the source images, which you can perform either manually or automatically in a layer stack. Manual image alignment can be time-consuming, but many specialty stacking and multi-function image process-

ing programs now offer automatic alignment functionality too. Alignment is part of the Photomerge tool in *Photoshop* and *Photoshop Elements*, both of which are capable of recognizing whether your images are part of a sequence or a panorama. If you have already loaded your images into a stack, use the Auto-Align Layers command in the Edit menu to align them.

Once you have aligned your images, you can check and adjust the results manually and discard any unwanted layers. So what can we do with a stack of aligned images? If the stack consists of similar photos without changes in exposure or focus parameters, there are three main choices:

1. Reduce noise and increase dynamic range
2. Simulate a long exposure
3. Create an HDR image

Reducing Image noise Using Stacks

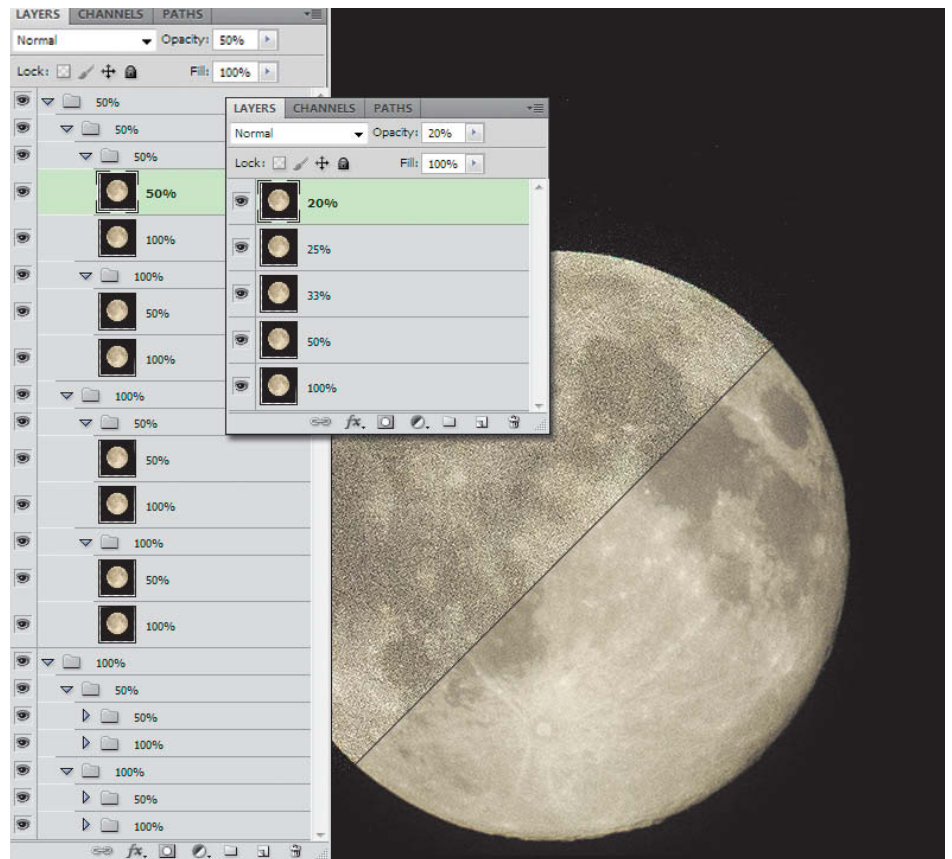
If you are shooting in low light and without a tripod, you will have to decide which shutter speed to use and which ISO value to set in order to prevent camera shake while keeping image noise to a minimum. If the camera's exposure meter recommends an exposure

time of one second at ISO 100, shooting shake-free photos handheld will be virtually impossible. It is usually possible to shoot handheld using a standard lens at exposure times of 1/30 second and less. However, increasing your shutter speed from 1 to 1/30 second implies increasing your ISO value to 3200 if you want to use the same aperture. With the exception of a very few high-end models, most cameras produce unacceptable amounts of image noise at these kinds of ISO speeds.

One solution to this problem is to shoot not just one, but 30 photos using the same settings (i.e., 1/30 second at ISO 3200). Merging all 30 shots into one using an image processing program will reduce noise in the finished image by a factor of 5. If everything goes according to plan, your merged, low-noise image will still be of a quality similar to one shot at the camera's recommended shutter speed of one second.

Image stacking is part of most astrophotographers' standard repertoire and often involves merging as many as several thousand frames shot using a hobby-grade camcorder. Specialist programs like *RegiStax*, *Fitswork* or *Giotto* merge multiple astronomical images and make fantastic detail visible that would

Calculating average brightness using layer opacity. Our example shows a deliberately noisy detail of an image of the Moon shot using a 300mm telephoto lens. The left-hand Layers palette shows our 16 source images grouped in pairs. In practice, and because virtually no other program except *Photoshop* supports layer groups, it is simpler to merge each pair of images at the outset. The degree to which you can reduce noise using this technique is astonishing. The fewer images you are merging, the quicker it is to superimpose them using decreasing opacity values from the bottom to the top of the stack – as shown in the right-hand layers panel.



otherwise remain hidden. But such highly specialized programs have a steep learning curve and reference small points of bright light on dark backgrounds to perform image alignment – a method that doesn't suit our purposes at all.

A common way to reduce image noise is to calculate the average brightness of each layered pixel. This value can be calculated channel for channel using any image processing program that supports layers and opacity adjustments. If you set opacity to 50 percent for the upper of two layers, this represents the average for both images. To calculate the value for n images, you have to set opacity to $1/n$, i.e., 25 percent for four images or 33 percent for a three-image stack. If you are averaging large numbers of images in a single stack, it helps to create groups, ideally consisting of two layers each. This allows you to use consistent opacity values of 100 or 50 percent and prevents rounding errors from spoiling your results. Logically, this technique is easiest to apply to image sequences that contain 4, 8, 16, 32 or 64 images, or any other number divisible by two.

Stacking techniques can theoretically be used to increase image resolution – not only because the results can be more highly mag-

nified without increasing noise, but also because demosaicing errors tend to be smoothed out when images are stacked. However, in order to reap these benefits, the stacked images have to be precisely aligned with a sub-pixel degree of accuracy that cannot be achieved using normal stacking techniques. The slightest shift between images causes the resulting image to appear unsharp which, in turn, negates any increases in image resolution you might be able to produce. Median stack mode, which is part of Photoshop Extended, is less prone to such image shift errors.

An important (and useful) side-effect of noise reduction is increased dynamic range. An averaged image contains much more shadow detail than its individual source images and – theoretically – dynamic range increases by one full f-stop every time you double the number of source images. Such results are, however, only achievable if you are processing 16-bit RAW source images. If you use 8-bit JPEG source material, the low (data) resolution will severely limit the amount of detail that can be produced by stacking.

However, if you want to compensate for low light (i.e., in situations where high ISO

values are necessary), JPEG images are an effective data source. Many low-end image processing programs do not support 16-bit layer or image processing. *GIMP*, for example cannot even open 16-bit images, and *Photoshop Elements* can only use 16-bit files as background layers. Programs such as *Photoline* (www.pl32.de) and *PaintShop Photo Pro* (www.corel.com) support 16-bit layers, albeit with limited processing functionality and (as yet) without the ability to align layer stacks.

Stack alignment is a standard feature in various stacking software packages. Here, we would like to introduce *PhotoAcute*, which is a standalone stacking program, and *LR/Enfuse*, which is a *Lightroom* plug-in. The *Extended* version of *Photoshop* (US\$800) also includes some useful stacking tools that we have not yet found in any other standard image processing package.

PhotoAcute

PhotoAcute is affordable and effective, and is available as a test version at www.photoacute.com. The full version, available for US\$19 for mobile devices, for US\$49 for compact cameras and for US\$119 for DSLRs, uses

The left-hand image is our original RAW shot of a full moon, shot at ISO 200 using a two-second exposure time and an aperture of f9. Here, the moon is already overexposed and there is virtually no visible shadow detail. Brightening the image increases detail, but also produces a lot of additional noise, as shown in the second image. By stacking 18 separate images, we reduced noise to an acceptable level while producing a pleasingly detailed image.

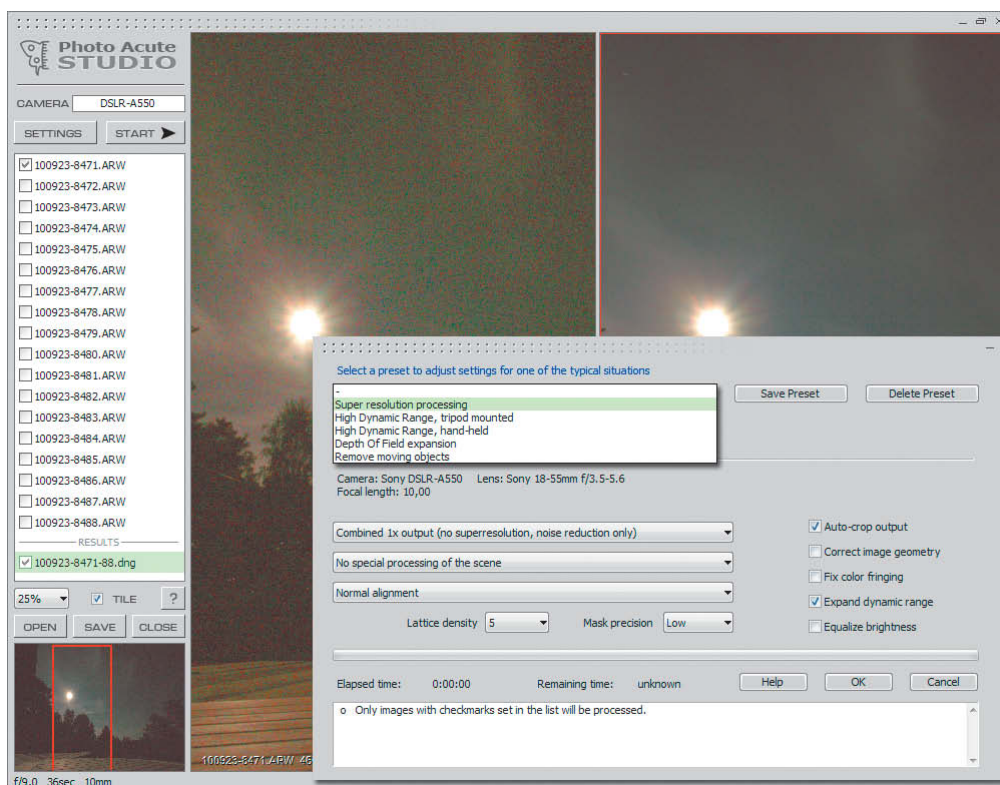


averaging techniques to produce “super resolution” images with double their original resolution. Whether this actually makes sense for your particular image is up to you to decide. It is easy to use (especially compared with most astrophotography programs), and the DSLR version is capable of processing RAW images and saving the results to JPEG, 16-bit TIFF, PNG and DNG formats. The other

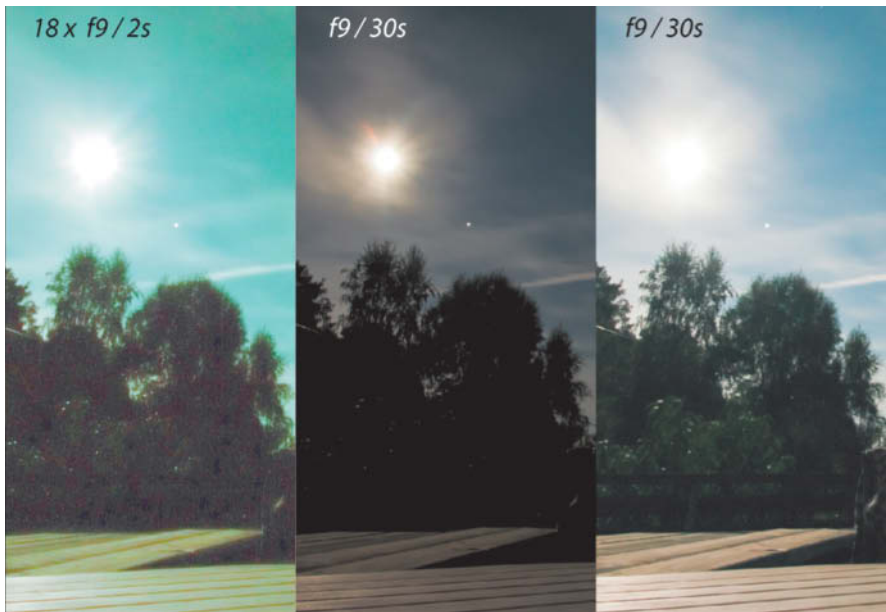
two versions only support JPEG. Other program options include moving object removal, HDR image production (without tone mapping) and focus stacking, which merges images shot using different focus settings to produce a single image with increased depth of field.

PhotoAcute is great for producing reduced-noise images and quickly and effectively align-

ing stacks of images. Although it can save individual aligned images for processing using other programs, it unfortunately doesn't support layers. Selecting your particular lens model is only necessary if you want to correct chromatic aberrations or lens errors. *PhotoAcute* is designed to read camera and lens models automatically from the Exif data stored with an image, but it failed to recognize both our

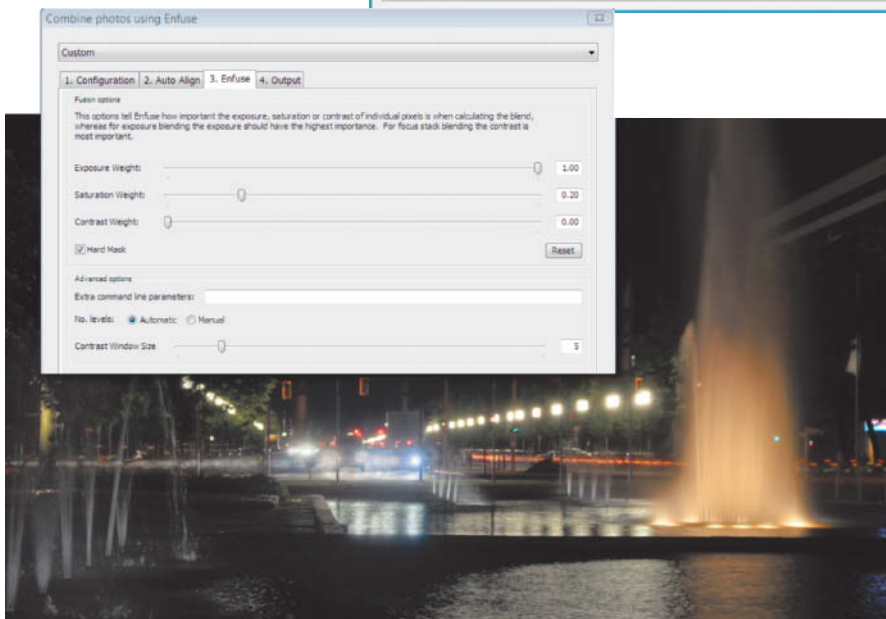
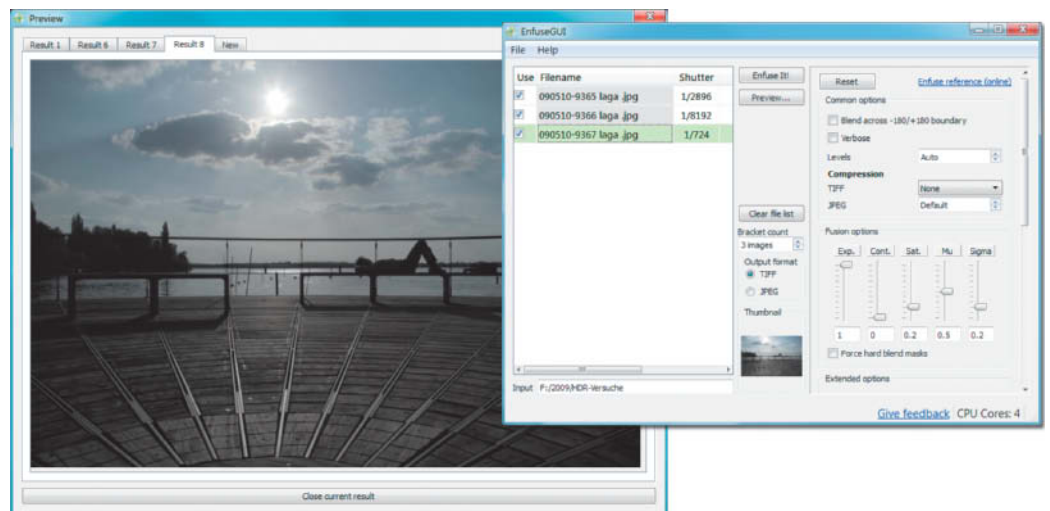


***PhotoAcute* produces reduced-noise images quickly and easily, and also supports exposure bracketing and focus bracketing sequences**

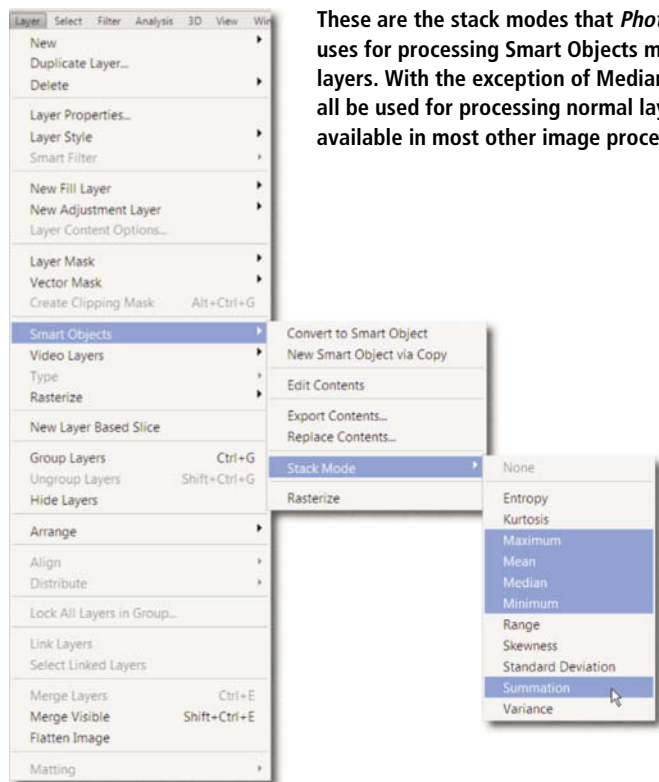


Our attempt to produce a “daylight” image from our moonlight shot produced heavy shadow artifacts. Using a dark frame might have produced better results, but the fact remains that even the best software tricks cannot produce detail where no light reached the sensor in the first place (see the image fourth from left). A 30-second exposure time captures sufficient light to allow us to brighten our image while preserving detail, although the Moon (in the final image on the right) is nonetheless extremely overexposed.

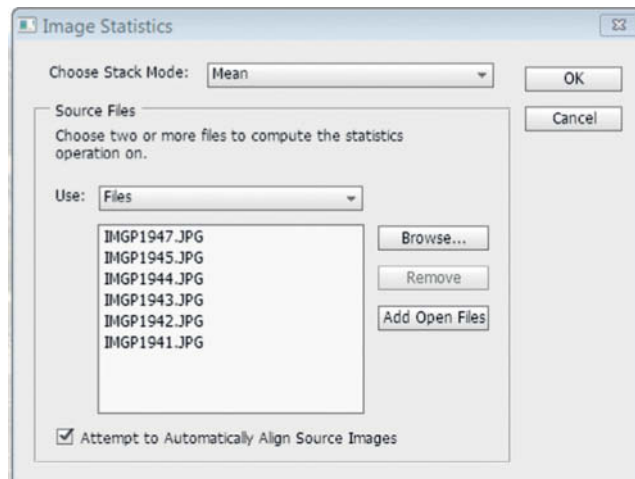
In this screenshot, EnfuseGUI is being used to increase contrast in source images shot using different exposure values. It can also be used to reduce noise in sequences of images exposed using the same values.



The Lightroom plug-in LR/Enfuse offers the same functions with an easy-to-use interface and can also be used to align images if required



These are the stack modes that *Photoshop Extended* uses for processing Smart Objects made of multiple layers. With the exception of Median mode, they can all be used for processing normal layers too, and are available in most other image processing programs.



The *Photoshop Extended* Image Statistics script (located in the File > Scripts menu) allows you to select, stack and render images in a single dialog. The resulting stack is a Smart Object.

camera and its lens. You can select these settings manually using the program's options, although the choice of available lenses varies from camera to camera. If your particular lens is not included in the list, select the most similar lens you can find, but do not expect the program to produce accurate lens error corrections or super resolution images if you use a second-best setting.

EnfuseGUI and LR/Enfuse

Enfuse is a freeware command-line program for stacking images according to criteria such as exposure, saturation and contrast. As well as allowing you to merge multiple source images into a single, high-contrast image without the feared artifacts that HDR tone mapping often produces, it can also combine images taken using different focus settings to produce a stacked image with enhanced depth of field – a technique used by a number of free and commercial panorama and stacking programs. User-friendly *Enfuse* GUIs with fast preview functionality are available for Windows and Mac at <http://software.bergmark.com/enfuseGUI/Main.html>. *Enfuse* does not have built-in image alignment functionality, so you will need to align your images using a different program before loading them. The reduced-noise images produced by *EnfuseGUI* are bright and highly-detailed, and

the program includes various fine-tuning and expert-level settings which are great for experimenting with. Unfortunately, *EnfuseGUI* doesn't allow you to save settings as presets, but the default values (exposure: 1.0, saturation: 0.2, contrast: 0) usually reduce noise to an acceptable level.

The LR/Enfuse *Lightroom* plug-in (www.photographers-toolbox.com/products/lrenfuse.php) is user-friendly and doesn't include any expert settings. The plug-in is distributed on a donationware basis and includes a built-in alignment algorithm. If you don't make a donation, the program limits the width of your output files to 500 pixels. Once you have selected your images in *Lightroom*, you can open the plug-in via the File > Plug-in Extras command and make your settings. You can save your rendered images as JPEGs or as 8-bit or 16-bit TIFFs, but not in 32-bit HDR format. It doesn't yet have a tool for removing moving objects, but does allow you to save your settings as a preset.

Photoshop and Photoshop Extended

We have already described how the Photomerge tool included with Photoshop and Photoshop Elements can be used to precisely align and merge multiple images for HDR or panorama applications. However, it does not

include rendering functionality for image stacks. The Photomerge Blend Images Together option selects the "best" parts of each of the images in the stack and pieces them together like a jigsaw puzzle. This is useful if you are making panoramas or performing focus stacking, but doesn't help at all if you want to reduce image noise. The only really useful Adobe noise reduction tools can be found in the Extended version of Photoshop in the Layers > Smart Objects > Stack Mode menu. These commands apply useful rendering algorithms to layer stacks: Mean mode saves us from having to use opacity values to calculate average brightness values as described above, and Median mode is useful for reducing image noise. A median value is the middle value of a sequence arranged according to size. The Photoshop Median algorithm suppresses severe deviations completely, making it a great tool for removing unwanted moving objects from image sequences. Minimum and Maximum modes are useful for producing certain special effects, and Summation mode is a great aid to producing HDR images. Median is the only one of these modes whose effect cannot be duplicated on regular layers using opacity settings or layer modes.

Photoshop has included 32-bit functionality since the release of the CS3 version. 32-bit mode makes the potential range of brightness in an image virtually unlimited, and

makes under or overexposure due to image processing virtually impossible. Summation stack mode automatically does away with the need to use opacity values to calculate average pixel brightness.

In practice, the technique works as follows: load your individual source images and align them if necessary. Select Linear Dodge (Add) blending mode for all layers except the bottom (background) layer. This mode adds all the pixel values together and produces a very overexposed-looking image – but don't worry, we are going to change that. Switch to 32 bits/channel using the Image > Mode command but do not confirm the resulting dialog that asks if you want to merge your layers, or you will end up with an image with clipped highlights as if you were working in 8-bit or 16-bit mode. Do not flatten your layers to save disk space until you have performed your 32-bit conversion.

The HDR image you have now produced contains the sum of the brightness values in your source images per pixel and per channel. You can now calculate the average of these values by dividing them by the number of layers (i.e., the number of source images). This is achieved without complex math by creating a new fill layer on top of your image stack. You can switch this layer to Multiply mode and then manually enter the inverse value of the number of layers in the three 32-bit value fields (i.e., $\frac{1}{4} = 0.25$, $\frac{1}{16} = 0.625$ etc.). Finally, you can convert your results back to 8-bit or 16-bit mode, confirm the merge prompt and select the Exposure and Gamma option in the HDR dialog that opens as a result. Your averaged image is now complete. If you want, you can record the entire workflow that we have just described in a Photoshop Action and repeat it at the click of a button.

Simulating Long Exposures

Sometimes, we wish we could make longer exposures than the situation or our equipment allow. In daylight, it is difficult to use exposure times longer than 1/30 second effectively, even with very small apertures. If you find yourself in this kind of situation and have neither a tripod nor a neutral density filter with you, the only solution is – you guessed it – shoot an image sequence that you can stack later on a computer. This time, we aim to simulate a long exposure by adding up the exposure times of all the images in the sequence – a technique that also has the useful side-effect of reducing image noise. This method can be used to add or enhance motion blur and produces effects such as “romantic” blurring of waterfalls and fountains. Long exposures can also help you to remove unwanted objects from your images.

Image Noise that Eliminates Itself

Ideally, the tonal value (or “brightness”) of a specific pixel depends only on the brightness of the subject itself, i.e., on the number of photons that reached the sensor at the moment the image was captured. If the same light hits neighboring sensor cells, it should also produce the same signal. However, in practice, slight differences in the physical nature of individual sensor cells mean that this is not always the case. The number of photons that hit each sensor cell within a specific period of time also varies slightly, causing a phenomenon known as “photon noise”, which is especially prevalent in cameras with small sensors and in low-light situations. Even in complete darkness, image sensors also produce signals known as “dark current” that vary in intensity from cell to cell and from minute to minute. The warmer an image sensor is, the more intense the dark current it produces will be (see also *Noise Know-how* in issue 2 of *c't Digital Photography*). An increase in sensor temperature of 7° Celsius doubles the amount of dark current produced. For this reason, astrophotographers often actively cool their cameras' sensors using Peltier devices. The camera's analog electronics produce additional “readout noise” and analog-to-digital signal conversion produces “quantization noise” to boot. Digital brightness values are always integer values, so an analog value that lies between 127 and

128 will sometimes be recorded as 127, sometimes as 128. This is a significant margin of error for an 8-bit analog-to-digital converter that covers a range of values between 0 and 255. It was only with the introduction of 12-, 14- and 16-bit A/D converters that photon and quantization noise began to play a less significant role in the quality of digital images.

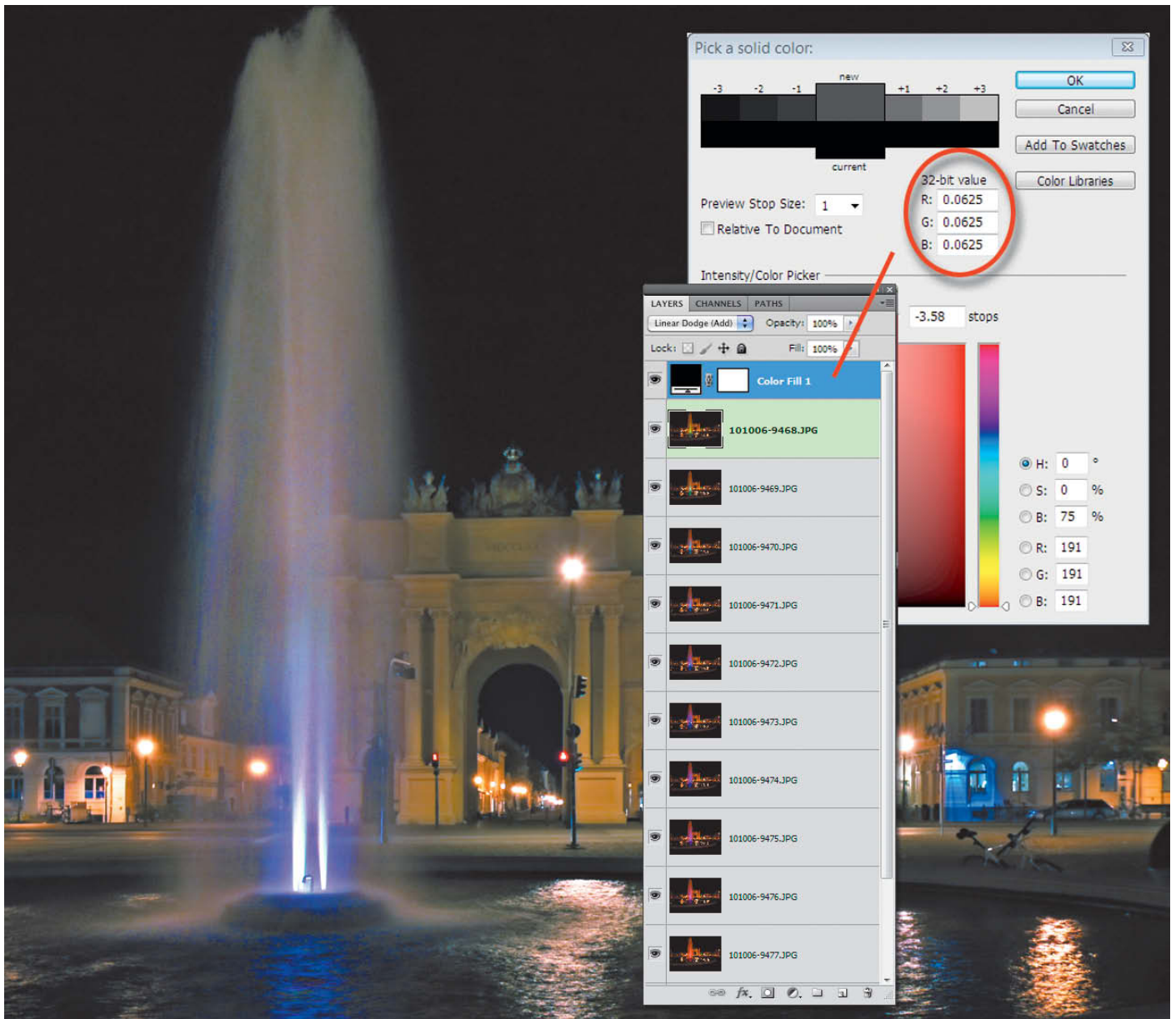
Photon, quantization and dark noise are subject to random variations. If you shoot a series of images in quick succession, you will find that certain pixels consistently darken and lighten in relation to a particular base value. These deviations can be eliminated to a degree by calculating the average values for each pixel. The more photos in the sequence, the more likely it is that these positive and negative deviations will cancel each other out.

However, this natural cancellation only works if the noise component is still present in the converted digital image. Some camera firmware simply cuts off weak or dark signals and the manufacturer then calls the result “noise reduction”. The shadows are then dark and noise-free but contain no detail whatsoever.

In addition to noise that varies with time, cameras also produce static noise (dark noise, for instance) that varies from pixel

to pixel and produces stripes or blotches in shadow areas. Stacking images amplifies this type of noise the same way a long exposure does. For this reason, for long exposures of one or two seconds or more, most cameras automatically take a second shot (a “dark frame”) with the shutter closed in order to produce an image of the sensor's static noise. The patterns created by the camera's inherent noise are then automatically subtracted from the image data. Many cameras don't shoot dark frames in continuous mode, even if the individual exposures are long. If you are shooting nighttime sequences, it is therefore preferable to use a programmable interval timer rather than continuous mode if you want to produce noise-optimized results. Alternatively, you can also shoot an additional frame of the inside of your lens cap which you can then subtract from your averaged, stacked image using Difference layer mode. An even better alternative is an averaged series of dark frames that eliminates random noise from the dark frame itself before it is subtracted from the stacked image. And, because static noise is temperature-dependent, it can be useful to shoot and keep averaged dark frames shot at various sensor temperatures. You can find a lot of useful information on the subjects of noise and sensor temperatures at any good astrophotography website.





Calculating average pixel brightness using *Photoshop*: the brightness values of the different layers are added together in 32-bit mode using the Linear Dodge (Add) blending mode and then divided by the number of layers using a separate fill layer set to Multiply layer mode. Here, we have 16 layers, giving the fill layer a 1/16 (i.e., 0.0625) brightness value. The source images were shot handheld using a shutter speed of 1/13 second at ISO 3200.

Mean is once again our stack mode of choice. The way the brightness of the individual source images is added together is similar to the technique used by image sensors when they record long exposures. The total is then divided by the number of images in the sequence. If it were possible to shoot an image sequence without any breaks for saving data, the result would theoretically be just as good as a single long exposure. However, every digital camera needs time to reset the shutter, re-meter exposure and focus, and to empty its data buffers. Most DSLRs also return the mirror to the down position between shots, only to raise it again before the next one. Compact cameras are capable of shooting much faster sequences than DSLRs because they don't have mechanical shutters. Some Casio compacts are capable of shoot-

ing sequences of 30 images at speeds of up to 40 images per second. If you manually set the shutter speed to its longest possible value (i.e., 1/30 second) for such a sequence, the results will be close to the theoretical "ideal" sequence without breaks between shots.

Breaks between shots appear as breaks in the movements portrayed in the rendered image and can, for example, produce visible breaks in the light trails of moving cars. This type of effect is less irritating if you are stacking images that contain large, uniformly colored shapes or rough textures. Rendered sequences are ideal for producing simulated long exposures of moving water. Experiment with Maximum stack mode to transform a trickling brook into a rushing river, or use Minimum mode to reduce bright reflections and

increase the transparency of the water in your images.

Using Image Sequences to Produce HDR Images

If we can use image sequences to produce simulated long exposures, it seems logical to use the same source material to produce HDR images too. You can use a sequence of 16 images to produce a series of three HDR source images with exposure increments that differ by two full f-stops. In this case, we add together the pixel values that we averaged in our previous examples. Stacking two images doubles the brightness of the result and is equivalent to doubling the exposure time. Continuous addition soon reaches the limits of image saturation, the same way an image sensor can no longer capture detail above a certain level of subject brightness. For an 8-bit image, the maximum recordable tonal value is 255 – a value that is often used to deliberately overexpose HDR source images to produce maximum shadow detail in the results.

To produce three HDR source images, select a single image from the original sequence to be your darkest HDR source image and copy it. The middle image (at +2 EV) can be produced by stacking four individual images, and the brightest image (+4 EV) by adding all 16 original images together. To achieve less noisy results, average the brightness of several source images to produce your first two (HDR) source images. For example, you could produce the darkest one by averaging all 16 source images and the middle one using a mixture of averaged and summed source material. In principle, you can combine opacity settings and the Addition layer mode in just about any image processing program, but before you start experimenting, we need to address a different issue, namely: gamma.

A gamma value describes an amount of implicit correction made to the colors in an image by camera firmware or a RAW converter. The important thing to remember here is that the relative brightness of the tonal values in an image file is greater than that found in the original subject. If we were

simply to stack the images and add their brightness values, the result would be much too bright – and the larger the number of images in the sequence, the worse this problem becomes. What we need to do is remove the gamma correction before we stack our images. If you have access to Photoshop, a more elegant way of achieving the same thing is described later in this article.

Let's now look at the basic steps involved in correcting gamma distortion using everyday image processing software – a procedure also known as linearization. We use the midtones (or gamma) slider in the Levels correction tool to set a value of 0.45, which is the inverse of the standard system gamma value of 2.2. Our experience has shown that we actually achieve better results using a correction value of 0.5. Remember to apply your correction value to every image in your stack and to brighten your rendered result using its inverse – in this case, 2.0. Don't worry if this makes your stacked image even brighter, as HDR programs are designed to process source material that is gamma distorted.

High Speed Cameras

The Casio EX-F1 was capable of shooting burst sequences of 6-megapixel images at 60 fps (frames per second) long before most high-end camera manufacturers thought of building double-digit burst modes into their products. The current crop of Exilim cameras can shoot 9-megapixel images at burst rates of up to 40 fps, although they do take a break to save photos and empty their data buffers after every 30 shots. These high-speed specifications are

unique to Casio, and the Exilim range of cameras also includes some interesting built-in serial processing features. The "Best Shot" mode records a sequence of images and automatically renders an improved image from the results. "High Speed Night Scene" mode recognizes whether the camera is mounted on a tripod or is handheld and automatically lengthens the shutter speed or switches to burst mode accordingly. "Best Shot High Speed Lighting" mode

produces higher contrast and optimized detail definition for shots that contain shadows and brightly lit details. To achieve a higher dynamic range, the camera combines multiple shots with different exposures into a single photo with optimum exposure and without the HDR artifacts common in other auto-HDR images. However, brightened shadows shot in this mode often contain a lot of visible noise. Our manual stacking techniques still produce better results, due also to the larger number of source images we use.



The Casio Exilim EX-FH25 (illustrated here) and EX-FH100 models are capable of burst shooting a maximum of thirty full-resolution frames at 40 fps. Burst shooting does not support RAW format. The camera's video mode supports shooting rates of up to 1000 fps at VGA resolution.

Some Sony cameras include similar features called "Handheld Twilight" and "Anti-shake". Here, the camera takes a sequence of six images and renders them internally. Sony claims that this method reduces noise by up to 50 percent. Fujifilm includes a similar four-shot sequence feature called "Pro Low-light" in some of its cameras, as well as a feature called "Motion Remover" that uses five-shot sequences at half of the camera's nominal resolution to remove unwanted moving objects. Fuji allows you to select a shooting time between 0.5 and 10 seconds for the sequence.

The Casio Exilim EX-FH25 is capable of shooting a virtually seamless sequence of 30 images at a shutter speed of 1/30 second, shown here in the smaller image on the right. In contrast, the Sony Alpha 550 DSLR shoots similar sequences with breaks between shots that are almost as long as the 1/13 second shutter speed itself. Both of these images were produced by stacking three source images from the original sequence, which means that the horizontal stripes were produced by a single car in both cases.



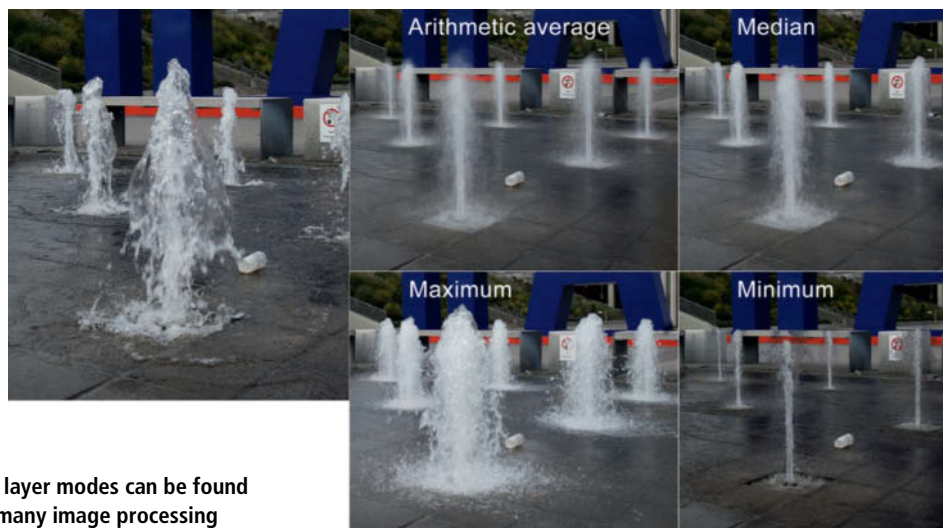
The differences between a photo shot using a "real" long exposure of 1/8 second and an artificially lengthened exposure made by stacking a sequence of eight images shot at 1/60 second are obvious. The discrepancies are caused by the imprecision of the gamma correction process, the inevitable noisy shadow detail produced by the shorter shutter speed used for the image sequence and the non-linear nature of camera re-

sponse curves. Most camera firmware automatically increases image contrast to produce punchy-looking images, brightening highlights and darkening shadows whether the camera's automatic correction features are switched on or not. Response curves have nothing to do with gamma curves and vary from camera to camera. They need to be precisely accounted for if you want to produce accurate results. If you know the shape of

your camera's response curve, you can create a color correction curve to mirror it and thus eliminate its effects. Measuring a response curve is possible, but is too complex a subject to address here.

Most importantly, make sure that you perform the entire workflow, starting with RAW conversion, in 16-bit mode. For this to be possible, your image processing program needs to support not just 16-bit image view-

Four different combinations of 18 source images using various stack modes. The image on the far left shows one of the source images, shot using a shutter speed of 1/200 second.

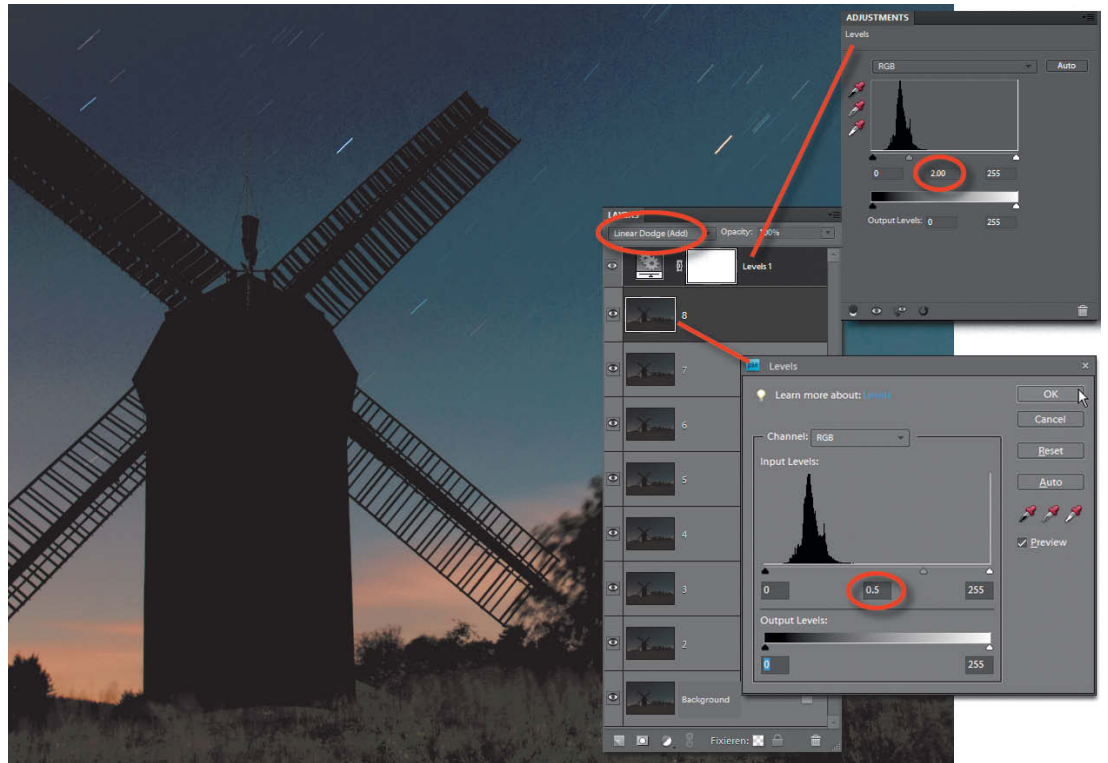


Maximum and Minimum layer modes can be found under various names in many image processing programs. *Photoshop* calls them Lighten and Darken, and also offers the alternative Darker Color and Lighter Color modes. To apply a mode to a stack of images, you have to select it individually for all of the layers in the stack except the bottom (background) layer.



Our 10 source images were shot at ISO 400 using a shutter speed of 30 seconds and an aperture of f5.6. The effective exposure time for the finished image is five minutes.

Stacking eight source images using approximate gamma correction. The midtones on each layer are adjusted using a value of 0.5 and the layer mode for each is set to Linear Dodge (Add). The resulting image is subjected to a Levels adjustment using a value of 2.0 on an adjustment layer added to the top of the stack. *Photoshop Elements* only supports 8-bit layers and is therefore not always suitable for adjusting darker images like this one, although the color artifacts the program produces are often quite attractive!



ing, but also 16-bit layer processing, which unfortunately excludes *GIMP* and *Photoshop Elements* from the outset. *Photoline*, *PaintShop Pro* and *Photoshop* (including some older versions) are the best candidates for the job. While it is not strictly necessary to save your intermediate stacked images in 16-bit format, it helps if you do. Most HDR programs can process both 8-bit and 16-bit source files. If the stacked images still contain Exif data from the original shoot, this can cause problems. *Photoshop's* HDR module fails if the Exif data are not appropriate to the image being processed. Many HDR programs allow you to enter exposure data manually and some, such as *Photomatix*, detect camera data and lens settings automatically.

Quick and Easy HDR

There are faster and more precise ways to produce HDR images than the methods we have just described, although using the *PhotoAcute* HDR tools is not one of them. Like most other conventional HDR programs, *PhotoAcute* expects you to provide it with a sequence of differently exposed source images. It can produce reduced-noise images from simple image sequences but is not capable of enhancing their dynamic range, except by simple "stretching" of the image histogram.

Once again, we turn to *Photoshop's* 32-bit mode, its native HDR processing mode. The range of 32-bit tools included with *Photoshop* is improving steadily from version to version, although the tools we need have been part of the package since the introduction of CS3.

Load your images into a stack and convert the whole stack to 32-bit. The images are once again summed using the Linear Dodge (Add) layer mode. You can automate this step by recording it as an Action. If you are using *Photoshop Extended*, you can also convert your stack into a Smart Object and use Summation stack mode. The result will be the same in both cases, although the Smart Object variation takes longer to process and uses more disk space.

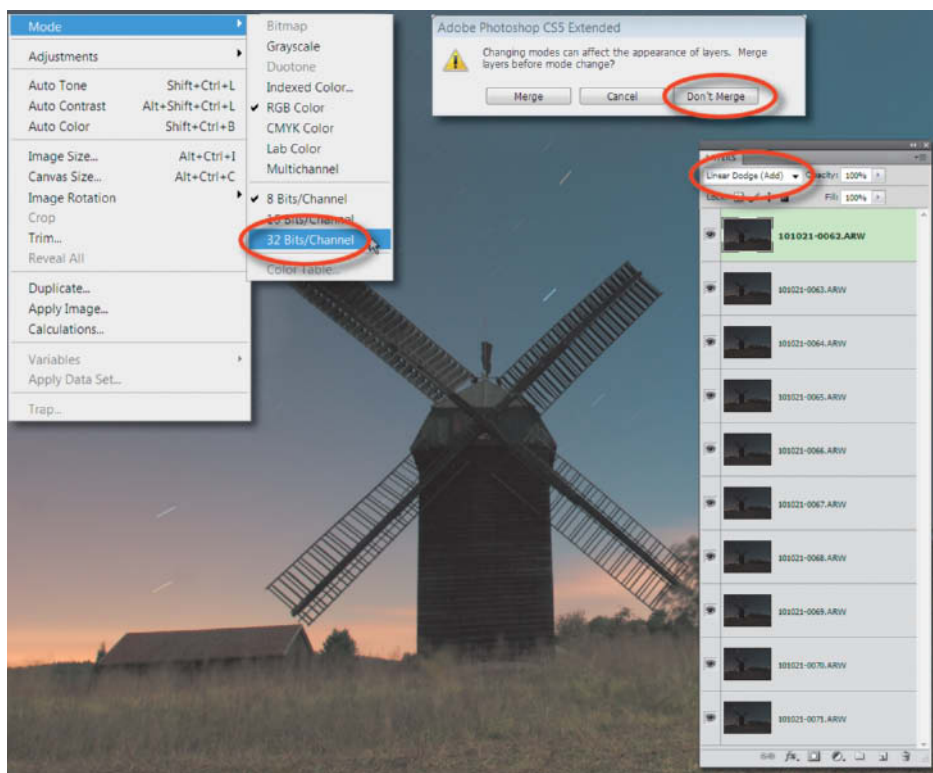
And that's it – your HDR image is finished. You don't have to create a multi-stage stack consisting of differently-exposed source images, and you don't have to compensate for gamma distortion. In 32-bit mode, your images are stored and processed in a linear color space. The only individual characteristic of the source images is the response curve of the camera used to shoot them, causing the finished HDR image to have slightly more contrast than the original scene. However, because tone mapping affects image contrast, these differences do not significantly affect the appearance of the final image. If necessary, you can also adjust or delete individ-

ual source layers in order to remove unwanted movements or artifacts. Most specialized HDR programs don't offer this degree of flexibility.

Photoshop has its own tone mapping module that opens automatically when you convert a 32-bit image to 8-bit or 16-bit. To use this module, confirm the dialog that asks if you want to merge your layers. If you want to use a different program to perform your tone mapping, you will have to merge the layers and save your image in an HDR format, such as .exr or .hdr.

Using Median Mode to Eliminate Moving Objects

Long exposures usually produce motion blur, whether "real" or stacked. The stars look quite pointy with the 30-second exposure times in the source images shown in our example overleaf, but appear as light trails in the stacked image. Many HDR programs include tools for automatically eliminating unwanted movements, although the results are often less than perfect. *PhotoAcute* includes options for completely removing unwanted movements as well as for including moving objects from a selected source image. The quality of the results depends on the quality of your source material, and there are no options for manual intervention once you have



The quick way to make HDR images from image sequences using *Photoshop*: load your source images as a layer stack, convert them to 32-bit mode and set all layers to Linear Dodge (Add) blending mode

started the process. Our attempt to remove the light trails caused by the stars was a complete failure, but we managed to produce acceptable results by using the stars from the first image in the stack. The stars remained clear while the other, stationary parts of the image were successfully summed to increase dynamic range. The artifacts caused by removing some pixels are only visible if we zoom into the finished image.

We managed to produce better results using Median stack mode (available only in the *Extended* version of *Photoshop*), which was mentioned at the beginning of this article as a useful alternative to Mean mode. Median mode reduces noise just as effectively as Mean mode and, because the individual pixels are not summed, the resulting image is sharper. Moving objects that cover less than half the area of the frame are removed, making it possible to photograph a cloudless night sky with virtually no interference from stars or airplane lights, regardless of the effective shutter speed. We then added a single photo from the original sequence to the stack in Lighten layer mode and copied the stars back into our stacked image. The stars thus appear just as sharp in the stacked image as they do in the original.

32-bit mode is not an essential part of this method but can help to further reduce noise. If you want to use 32-bit mode, convert your image to a Smart Object before you trans-

form it. The results of using Median mode are not brighter than the individual images in the stack, but you can brighten the finished image by adding an appropriately adjusted fill layer (in Multiply mode) and entering the number of images in the stack in the three RGB value fields. The maximum possible value here is 20, so if you have more than 20 images in your stack, you will need to use multiple fill layers. These function multiplicatively, which means that if your stack contains 30 images, the RGB values in your first fill layer need to be set to 20, while those in the second should be set to 1.5 (i.e., $1.5 \times 20 = 30$).

Conclusions

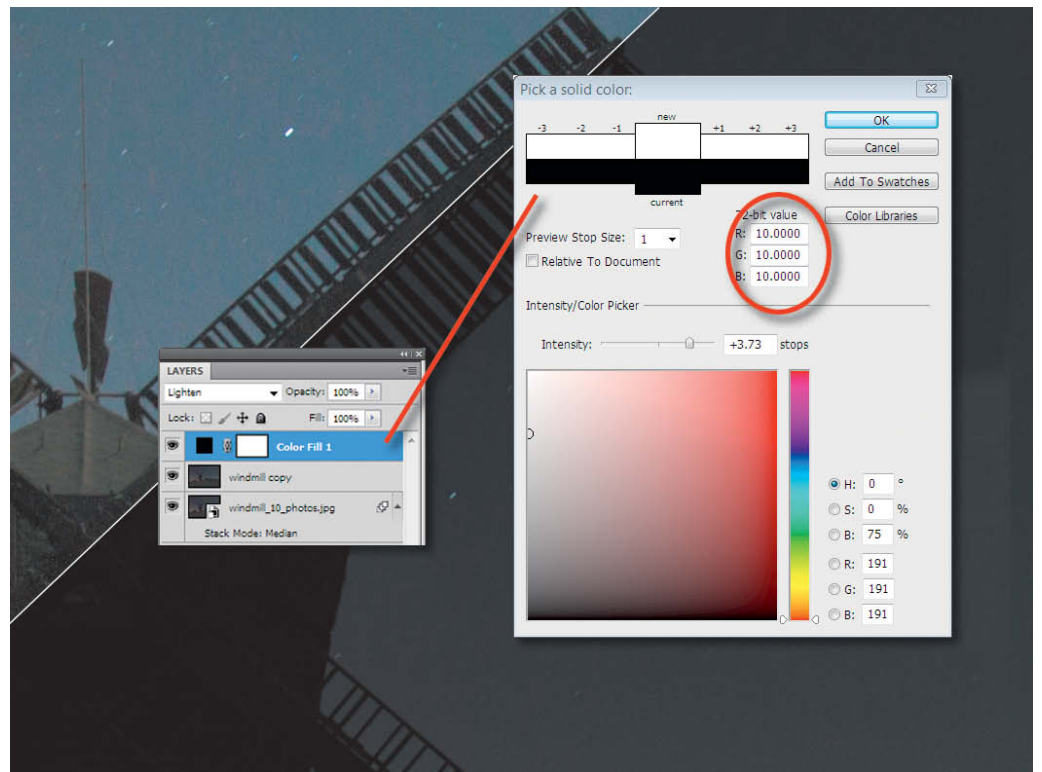
Image stacking is a great way to optimize images and produce interesting effects. Some manufacturers have begun to build stacking functionality into their camera firmware, although camera electronics are still too rudimentary to render more than a handful of images. In-camera processing can take a long time, too, and the results are not really of professional quality, often because this type of functionality is built into cameras with small image sensors.

Processing stacks shot using APS-C (or larger) sensors offers more flexibility. The number of images in a stack is, theoretically,

unlimited, and processing doesn't take as long. You can also make manual adjustments to individual layers or remove them completely.

Noise reduction, contrast enhancement and object removal are all available as built-in camera features now, but simulated long exposures have yet to be included as standard. This is puzzling, because large numbers of appropriately short exposures are ideally suited to stacking and are technically simple to produce. We have already described how to produce pseudo-long exposures manually, and things get really interesting once you start to use simulated long exposures or image sequences as the source material for HDR images. This approach prevents camera shake and saves the time and effort involved in adjusting your camera settings between shots. Unfortunately, most built-in bracketing functionality is constructed around exposure increments that are too small and sequences that are too short for producing effective HDR material. A normal sequence of photos requires just a single set of exposure settings and, if you are not shooting at night, a single exposure time that you can shoot handheld. Alignment tools can be used to eliminate the framing discrepancies that are usually part of sequences of handheld photos, and you can even eliminate the motion blur that would be unavoidable if you were to shoot using the effective exposure time

An additional image, slightly darkened to avoid including brighter noise artifacts and switched to Lighten mode (the center image in the illustrated panel), gives us sharp stars in a photo that has an effective exposure time of five minutes. Median stack mode removes the light trails from the 10 individual source images, which we converted to a Smart Object (the lower layer in the illustration). We used a fill layer with brightness values multiplied by a factor of 10 to provide the appropriate brightness in the finished, stacked image. The image detail in the top left corner of our illustration shows the result of this brightening step.

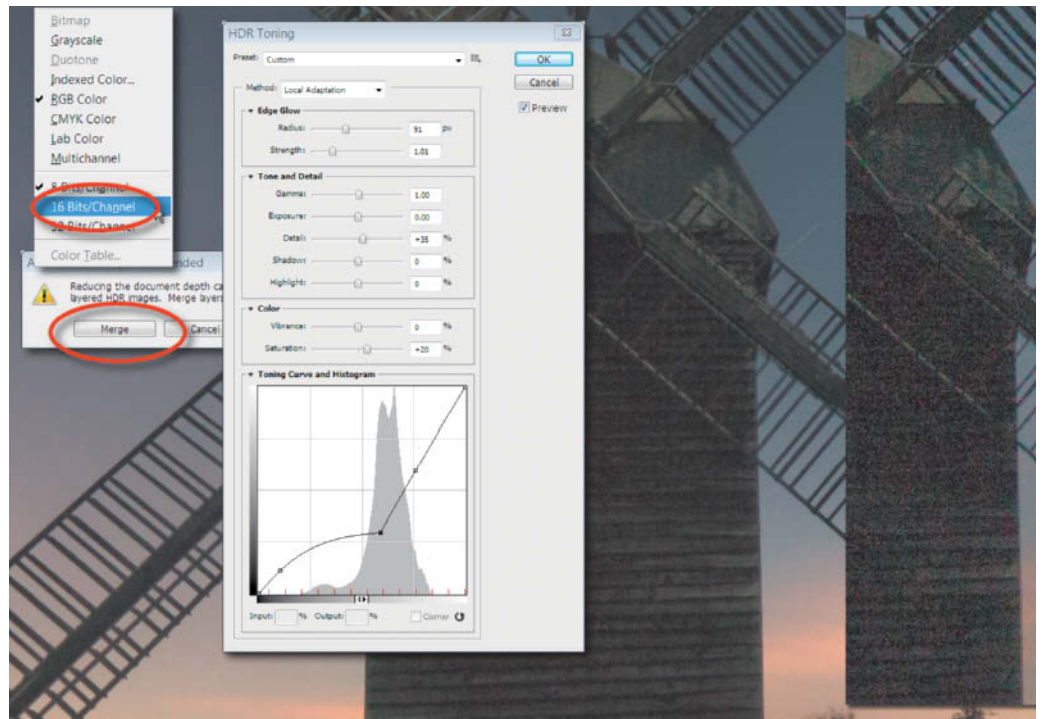


that stacking allows you to produce. We have already described how to do this using standard software tools, but the Swiss photographer and programmer David Kaplan has perfected the technique and incorporat-

ed the results into proprietary software that he uses to produce images that he calls "Neo HDR". A look at his website (www.kplan.ch) shows that Kaplan really has begun to explore new photographic territory. Previously,

long exposures and motion blur were inseparable twins but nowadays, digital techniques allow us to produce super-sharp details using extremely long effective shutter speeds. (keh) **ct**

Photoshop performs tone mapping during conversion back to 8-bit or 16-bit. In this image, we have enhanced shadow detail without spoiling the overall look of the image. Simply brightening the shadows in the original image produced too much noise, as shown in the right-hand image.





Ralph Altmann

Photoshop Elements 9

Just six months after the introduction of the all-new Creative Suite, Adobe has introduced a new version of Photoshop Elements. In this article, we provide an overview of what's new and what's been improved in the latest Elements release.

Easy to learn, simple to operate, great results: these are the basic expectations that most hobby photographers have of their image processing software, and precisely the qualities that Adobe continues to provide with each new release of *Photoshop Elements*. User-friendliness has taken a further step forward in version 9, which includes a number of enhanced tools and wizards that will help beginners and experienced users alike.

A typical digital workflow that an image undergoes before it finds its way into print or onto *flickr* consists of four major steps: loading and organizing (for example, into a particular album), processing, preparing for output and, finally, publishing.

These are also the four main areas of the *Elements interface*, found in four dedicated tabs called Organize, Edit, Create and Share. *Elements* actually consists of two separate programs, one for organizing and one for editing images, although in the latest version they are more closely knit than ever before. The Edit workspace contains three tabs of its own, and the assumption is that by the time you have started editing, you will have long finished any organizing you may have wanted to do.

Organizing Your Media

The *Elements Organizer* is an offline media browser for managing photos, audio and

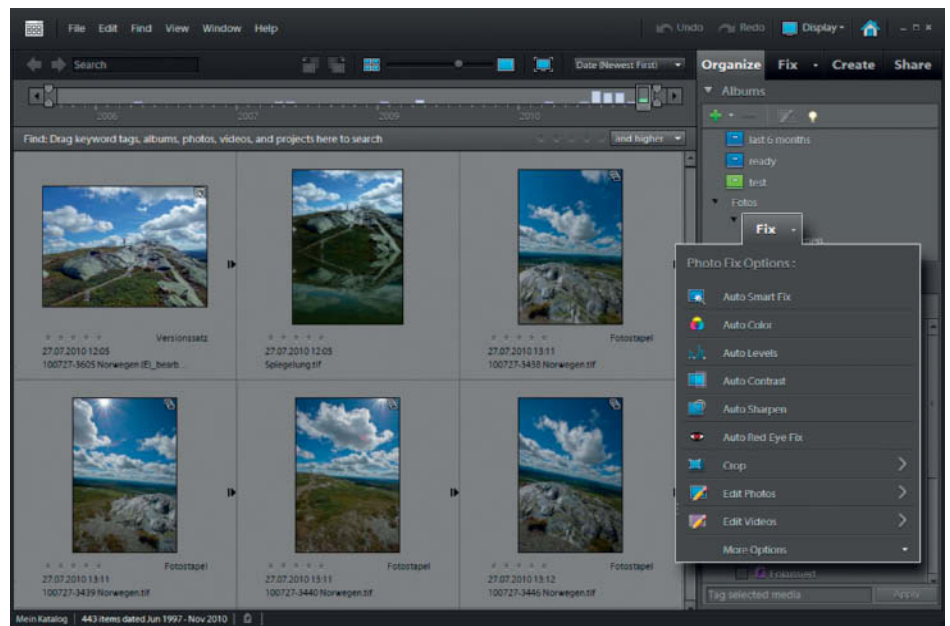
video files and PDFs. In this case, "offline" means that the program is also capable of managing media that you have saved on CDs, DVDs or external hard disks. *Elements* saves copies of all the media you are currently managing and prompts you to update external storage if you make changes to files that aren't stored locally. But before anything can happen, you have to import your media. During import, the program analyzes media content and produces thumbnails of all the images it finds. There are various import options that allow you to arrange photos in stacks according to the date they were taken or their visual similarity. The options themselves cannot be

changed, but you can edit stacks once they have been sorted.

Elements also includes a face recognition module. Media are sorted into albums, which can also be categorized hierarchically, although it has to be said that this feature is only really new for Mac users. An interface that looks a lot like Explorer or Finder shows the user where files are physically located and the program can check automatically for changes in selected folders. The automatic image analysis functionality recognizes not only faces, but also formal qualities of images, such as sharpness, overall quality and contrast, as well as certain types of composition, including close-up or wide-angle. This functionality is good but not great, and doesn't always recognize image content correctly.

Image attributes are stored in tags similar to keywords, which can be used to filter your image catalog. However, there is still no functionality for sorting images directly in the program window, even according to filename. Another obvious omission is the lack of an image count for closed stacks.

The organizer's Quick Fix feature offers six options for automatically correcting your images, including smart color and lighting corrections, and other popular tools such as red-eye removal. The big advantage of quick fixes is that they can be simultaneously applied to multiple images. Here, *Elements* automatically produces copies of your original images called "versions", which are saved in the same folder as the originals. These copies are automatically labeled as fixed and are given a



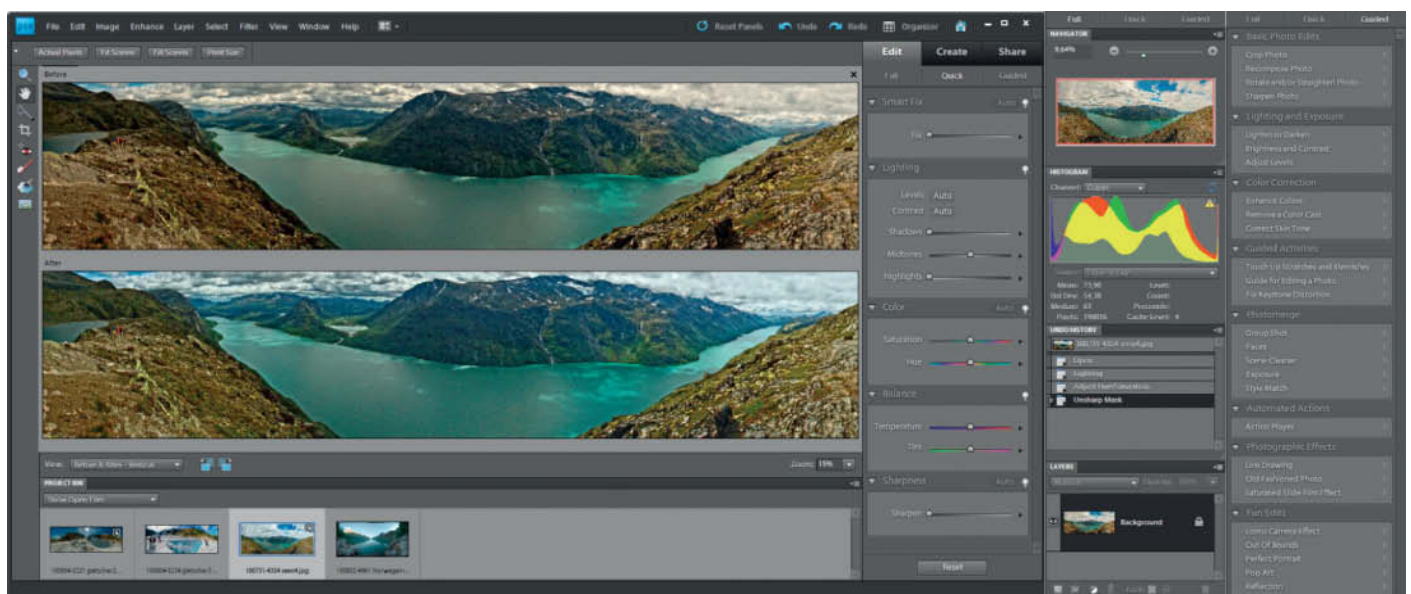
The Organizer tab includes Quick Fix mode, which allows you to apply fixes simultaneously to multiple images

new, serial number. The Quick Fix tab also allows you to open single or multiple images in the *Elements* editor, where you can continue correcting your images automatically or use the wide range of manual correction tools included with the program.

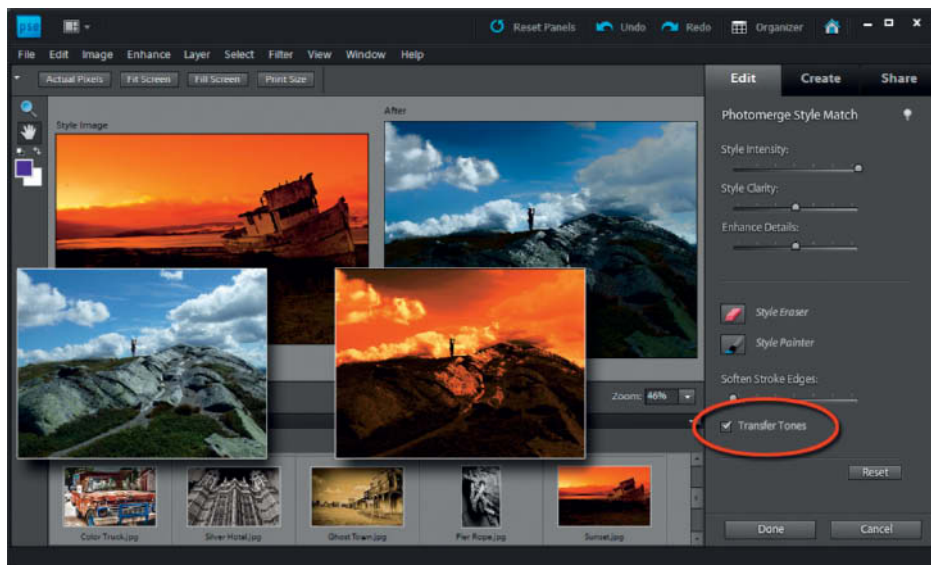
Editing Images

You can open multiple images in the *Elements* editor, but you can only edit one

image at a time. All open images are shown as thumbnails in the Project Bin at the bottom of the program window, where you can also search through your albums and catalogs (but not Smart Albums). The Edit panel is divided into three workspaces, but only the Full Edit workspace allows you access to the program's full range of image editing tools. The Quick Edit panel includes sliders called Smart Fix, Lighting, Color, Balance and Sharpness. Although this panel looks very similar to



Like *Photoshop Lightroom*, Quick editing mode in *Elements* includes before and after views of the image you are working on. The Full and Guided editing panels are shown on the right.



The two main Style Match options: you can apply brightness or tones – or both – from the selected style template (shown here in the background on the left). The left-hand foreground image is the original, while the version on the right shows the result of applying the Transfer Tones option. The right-hand background image shows the effect of transferring brightness only.

the one in *Photoshop Lightroom*, it only allows you to correct one image at a time. There are Hue And Saturation sliders for adjusting white balance, although the White Balance tool in the Enhance > Adjust Color > Remove Color Cast menu is quicker to use once you have located it.

The Guided Edit panel is divided into various tasks. Clicking a task first opens a window that explains how it works – sometimes even

with graphic examples. The panel includes all the familiar Photomerge tools except Photomerge Panorama. The Photomerge Group Shot Guided Edit helps you to produce a perfect group photo from individual source images, while the Faces Guided Edit is designed for constructing fun portraits using individual facial features taken from other images. The Scene Cleaner Guided Edit is great for removing unwanted moving objects from a scene,

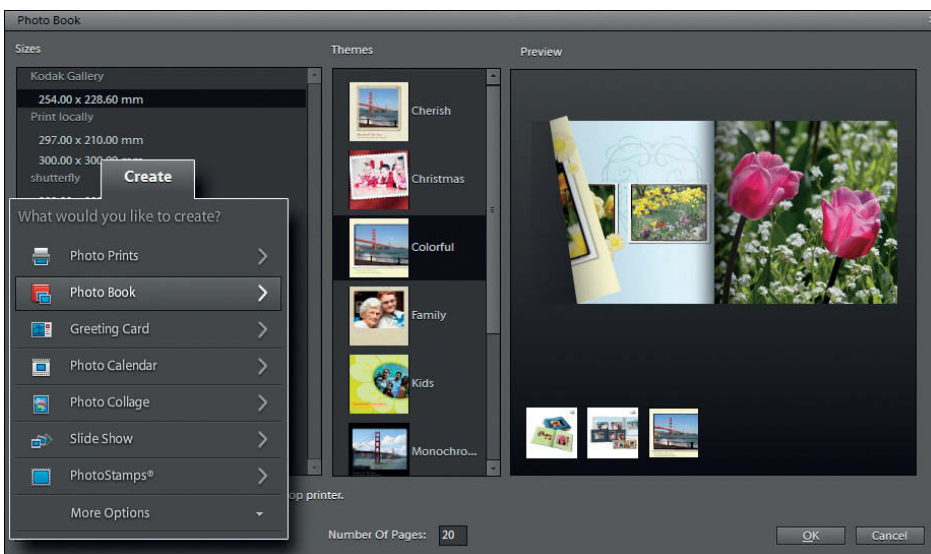
while the Exposure Guided Edit is used to merge sequences of differently exposed photos into a single, well-exposed image – a function that shouldn't be confused with HDR imaging.

The last two tools mentioned here require you to use one or more source images of the same subject. The program is capable of aligning source material semi-automatically using up to three markers positioned by the user. Once you have placed your markers, all you have to do is select the image areas you want to include in the final image. Unfortunately, the program can only determine the borders between original and new material automatically, and often produces incorrect overlaps that cannot be edited.

Elements places the merged image in a new layer on top of the original. We expected it to output the layer masks it uses for the merging process the same way the Photomerge Panorama tool does, so that we could edit them manually if necessary. This functionality was actually available in *Elements 8*, although the program doesn't "officially" support layer masks. The way things stand, the merge tools built into *Elements 9* are little more than a gimmick and are not up to the task if faced with anything more than basic source material.

The new Photomerge Style Match tool is designed to apply the "style" properties of a selected source image to an image of your choice. It also includes Intensity and Clarity sliders for modifying the results. While it does allow you to exclude selected areas from the overall effect, it is only about as accurate as the equivalent functionality in the Scene Cleaner and Exposure tools. Style Match also requires you to load your chosen source image into the Style bin before you can use it, which seems unnecessarily complicated.

Elements analyzes the Style original's color, contrast and tonal range, which means that you can use just a color gradient or a monochrome Style template if you want. The default settings apply only the distribution of pixel brightness while preserving the original colors. If you select the Transfer Tones option, the colors are transferred too. This is a quick and effective way to apply black-and-white or sepia tones to color images, even though the tool cannot be applied to multiple images. The Guided Edit panel also includes the line-drawing, old-fashioned photo and slide film saturation (or "Velvia") effects that were already part of *Elements 8*, as well as five new "Fun Edits" called Lomo, Out Of Bounds, Perfect Portrait, Pop Art and Reflection. These simple names conceal some quite complex workflows and, although there are wizards to guide you through the entire editing process,



Photoshop Elements helps you to work without having to use the complex software provided by some online calendar and photo book services

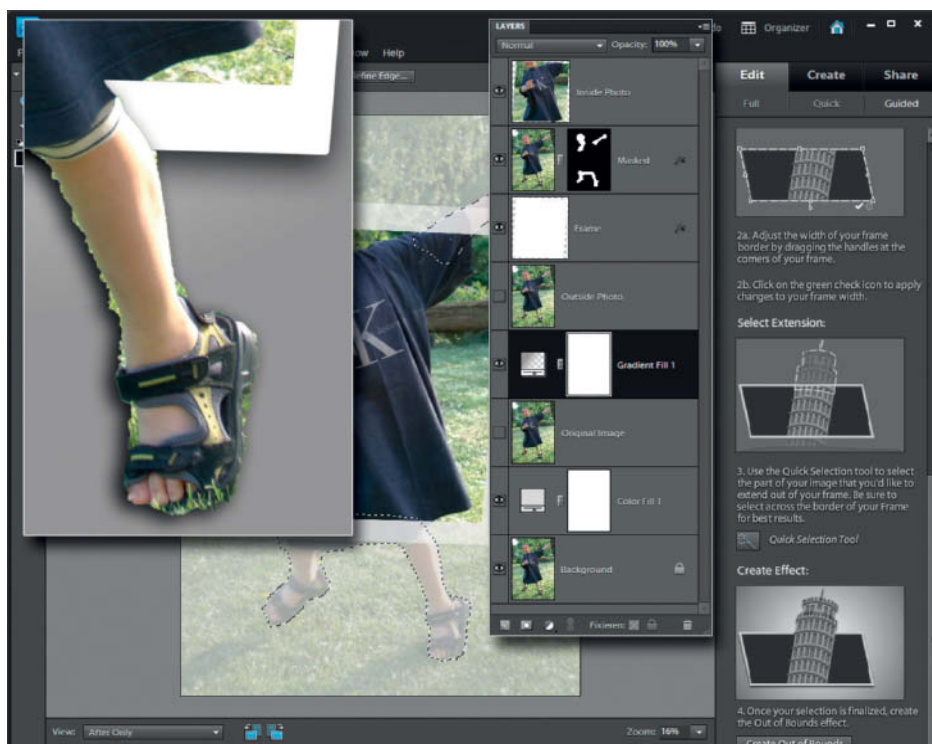
the tools are not aimed at *Elements* beginners. The Out Of Bounds edit is based on layer mask support, which is new in this version of *Elements*. Previous versions only allowed layer masks to be used on adjustment layers, or on regular layers by tricking the program into working around its own limitations (see issue 1 of *c't Digital Photography* (www.ct-digiphoto.com)).

Elements has included a player for applying prerecorded *Photoshop* actions since version 7, but still doesn't offer functionality for recording new actions. If you want to make your own actions, you still have to record them in a full version of *Photoshop*, taking care to use only tools that are available in *Elements*. It isn't at all clear why Adobe decided to take this route. Maybe they assume that there are enough older versions of *Photoshop* in circulation to make including Actions functionality in *Elements* redundant. The new version of *Elements* also includes the improved Spot Healing Brush tool included with *Photoshop*, which magically removes unwanted specks, blotches, telegraph wires and other details while invisibly repairing the image background. This is a huge improvement on the tried and trusted Clone tool. Nevertheless, the "professional results at the click of a button" that Adobe promises are not always as easy to achieve as the adverts would have us believe. For example, making clean selections using the Quick Selection tool is extremely fiddly if the differences between subject and background pixels are not clearly defined

The Create Panel

The third phase of an *Elements* project involves turning your processed images into a presentable finished product, which can be a greetings card, a CD cover, a calendar or a slideshow. The program includes a wide range of templates for these and other types of projects but – you have probably already guessed – it doesn't allow you to create your own templates or import templates into the list. You can, however, use saved templates individually. The program saves multi-page layouts in its own PSE format, but saves single pages in the *Photoshop* PSD format that can be read by a wide range of Adobe and non-Adobe applications. As an example, a greetings card could contain a "paper" background layer and additional layers for each photo and text element, making it adaptable without having to create a new project every time an element is altered or swapped out.

Elements 9 includes various templates, including a new one for creating photo calendars. But remember, with the exception of the KODAK Gallery service that you can use



The Out Of Bounds edit effect is a great demonstration of the power of layers and layer masks, but you nevertheless need to take great care with the selection brush (see the left-hand image above) if you want to get satisfactory results. The layers panel in the center shows the layers and masks that result from applying the tool.

directly from the program's interface, you will have to print your projects yourself. It is also possible that incompatibilities between *Elements* and the layout software provided by online print services will complicate the upload process, but only a trial run at your favorite lab will prove for certain whether there are any pitfalls.

The Share Panel

Photos are great for sharing, and the *Elements* Share panel offers a variety of ways to do so. Support for online albums and email attachments (via Adobe's own mail service) has been available in *Elements* for some time now, but the latest version also includes direct upload support for flickr, Facebook and KODAK Gallery. We would also like to see a tool for including the user's own selected online services in future versions of the program.

Conclusions

A full version of *Photoshop Elements* costs US\$99.99 while an upgrade from an earlier version costs about US\$20 less. The program is also available as a bundle with *Premiere El-*

ements for US\$149. It is up to you to decide whether the few improvements in the new version justify the investment. Compared with the previous version, *Elements 9* is something of a half-hearted update that is still missing a few features that we consider essential. For instance, 16-bit RAW support is now a must for most digital photographers, but *Elements* still only offers rudimentary 16-bit processing functionality.

On the other hand, the Spot Healing Brush tool saves a lot of time and effort during processing and is, as far as we know, unique to Adobe. In other areas, *Elements* lags behind the competition and the needs of its users, and the downside of its simplicity is its lack of flexibility. There are many cheap (or even free) programs available that allow you to automate regular tasks and workflows. On the positive side, *Elements* includes the powerful *Adobe Camera Raw (ACR)* RAW processing module, although the *Elements* version doesn't include Lens Corrections and some of *Photoshop's* other high-end tools. However, on balance, an upgrade to *Elements 9* is nevertheless the cheapest way for Adobe users to acquire the elegant and useful base functionality of the current 6.2 version of *ACR*. (keh) **ct**

Ralph Altmann

A Glossary of Digital Photography

A box with a shutter and a lens attached and a light-sensitive plate – the basic principles of photography haven't really changed since the medium was invented. But the degree of sophistication with which these three basic components are constructed and combined has changed a great deal. This article explains how the most important parts of a modern digital camera work.

Pixels

A pixel is the smallest individual element of image data and records basic RGB color information. Its size is variable and is defined by the size of the image it is part of when displayed or printed. If an individual pixel is enlarged too much, it appears as a single colored square.

The number of megapixels a manufacturer uses to describe a camera refers to the

number of pixels that make up each captured image, even though many people think it describes the number of photosensitive cells, known as photoreceptors, on the camera's image sensor. However, not every sensor cell provides image data and individual image pixels are produced using information from three or more sensor cells. A process called interpolation is used to increase the number of image pixels so that it is similar to the number of photoreceptors

on the sensor. The quality of the interpolation algorithms used, together with the size of each photoreceptor, determines the quality of the resulting image. Thus, stating that a camera has "12 megapixels" is about as meaningful as stating that a wallet contains "12 coins". The semiconductor industry is constantly developing processes for etching increasing numbers of photoreceptors onto image sensors, and the effect this produces is similar to trying to make a sum of money appear larger by converting it into smaller coins and bills.

You can only be sure that a "12-megapixel" camera will produce better images than a "6-megapixel" camera if you know that its image sensor is also twice as large. If the larger number of pixels is compressed onto a sensor of the same size, each photoreceptor will be only half the size of those found on the 6-megapixel sensor. The smaller the space available for each pixel on a sensor's surface, the more susceptible those pixels will be to producing image noise, and the lower the camera's dynamic range will be. Larger numbers of pixels also slow down image processing times and reduce the number of images that you can save on a memory card. As a result, the size of a camera's sensor says more about the quality of the images it will produce than the number of pixels it contains. Larger sensors are nearly always better – and more expensive – than small sensors.



Which would you choose? Pixels are like coins – more is not necessarily better.

Sensor Sizes

A few years ago, a full-frame image sensor the same size as a traditional 35mm film frame (i.e., one that measures 24×36 mm) was beyond the bounds of practical and economic reality for most photographers. The price of a semiconductor depends on its surface area more than on the density of the circuits it contains, and even today, full-frame sensors are only built into high-end cameras. Most digital compacts and DSLRs use much smaller sensors.

You might be thinking that if the mechanical and optical parts of a camera are reduced in size to match a smaller image sensor, then the camera in question should be able to produce images of a comparable optical quality to those that can be taken using a larger sensor used with scaled-up hardware. This assumption is true for the angle of view and focal length of a lens. Used with a small sensor, a 50mm standard lens (a focal length that represents the angle of view of the human eye) becomes a short telephoto lens, while a 200mm telephoto will have super-telephoto “paparazzi” qualities when used with the same small-sensor camera. You can calculate the *equivalent 35mm focal length* that is instinctive to most analog photographers by multiplying the focal length of a lens by a camera’s “crop factor”, which is equal to the mathematical ratio of the size of the camera’s sensor and a 35mm film frame. A 50mm lens mounted on a camera with a 2/3” sensor (i.e., one that measures approximately 6×9 mm) has a crop factor of 4, which makes it a 200mm equivalent lens.

The same calculation makes a 12.5mm lens equivalent to a 50mm standard lens when used with the same small-sensor camera. The same physical characteristics also make it possible to construct a lens with the same equivalent aperture range using smaller glass elements, which in turn means that lenses for cameras with smaller sensors are themselves physically smaller and therefore cheaper to manufacture than equivalent full-frame lenses.

The major disadvantage of smaller sensors is that they do not capture depth of field so well, because subjects and their surroundings remain the same size regardless of which camera you use to photograph them. The smaller the image sensor the larger the reproduction ratio (i.e., the size of the subject relative to the image), and the larger the reproduction ratio, the greater the depth of field you can produce. This makes it extremely difficult to use depth of field as a creative element when composing images using a camera with a small sensor. Depth of field is a

function of the third dimension (i.e., perpendicular to the image sensor plane), making it independent of the number of pixels in an image sensor.

Here is an example: the Leica lens built into some Lumix cameras has a maximum aperture of f2, which is unusually large for a zoom lens, but multiplication by the camera’s crop factor of 4 means that the camera can only produce depth of field similar to that produced by a 35mm camera at f8. This is called the 35mm equivalent aperture and only affects depth of field, not exposure. The same basic multiplication factor is also generally valid for subject distances. The reduction in depth of field at short subject distances is less obvious, but nevertheless visible. This effect can have advantages, for example in macro photography, where short subject distances are the norm and 35mm cameras often produce too little depth of field. Many digital compacts are capable of taking macro photos with reproduction ratios as large as 1:1 – a type of shot that used to involve a great deal of technical know-how and extra equipment back in the analog era. Small sensors in miniaturized enclosures also allow nature lovers to make digital films of all sorts of things, including, for example, an ant’s-eye view of life inside an anthill.

Sensor size and the number of pixels determine how much space each photoreceptor takes up on the sensor’s surface. In practice, the space available is also restricted by the electronic circuits that link the individual sensor cells. The width of a single photoreceptor in a quality sensor ranges from $6 \mu\text{m}$ (in the Sony Alpha 900) to more than $8 \mu\text{m}$ in the Nikon D700. Typical digital compacts have sensor cell widths of around $1.7 \mu\text{m}$, giving them a sensor surface area that is only four percent of the size of a quality DSLR sensor.

Lenses

The small size of lenses that can be used with small sensors is an advantage only if the lenses are capable of producing high-quality images. The smaller the sensor, the more obvious any chromatic aberrations or distortions produce by the lens will be. A good digital lens will produce sharp, well-corrected images, and will cause light to reach all parts of the sensor surface – including the extreme edges – as perpendicularly as possible, in order to avoid image quality loss caused by internal reflections and refraction. These particular characteristics are not necessary in analog cameras, so rest assured that “digital lenses” are a genuine boon and not just a marketing trick!

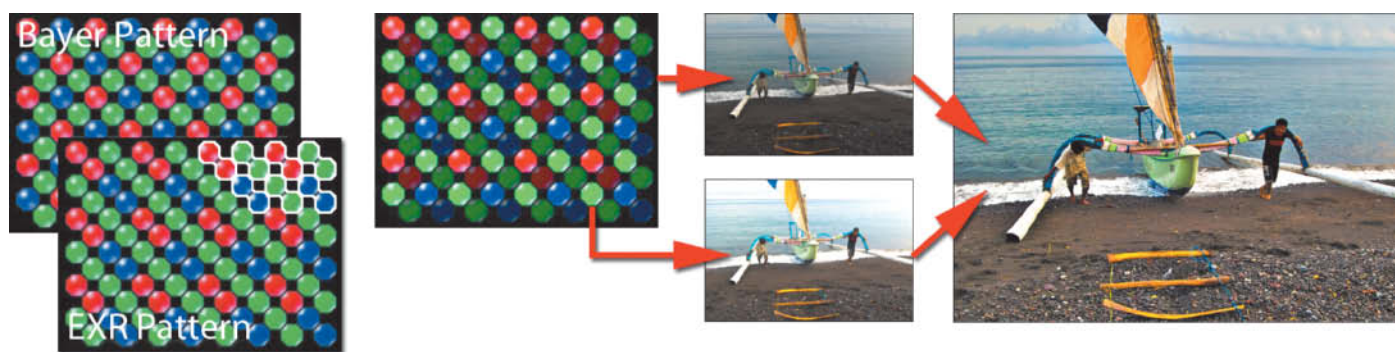


A comparison of sensor formats:

- (1) 36×24 mm (Full-frame format; e.g., Nikon D3)
- (2) 28.7×19.1 mm (APS-H format; e.g., Canon EOS-1D)
- (3) 23.6×15.8 mm (APS-C format; e.g., Nikon D300)
- (4) 17.3×13.0 mm (Four Thirds format; e.g., Panasonic Lumix G2)
- (5) 8.8×6.6 mm (2/3” format; e.g., Fujifilm FinePix S100FS)
- (6) 7.5×5.5 mm (1/1.8” format; e.g., Ricoh GXR)
- (7) 5.6×4.2 mm (1/2.7” format; e.g., Nikon Coolpix S600)
- (8) 5.4×4.1 mm (1/3” format; e.g., Sony DSC-T1)

Large numbers of pixels on a sensor produce resolutions that are higher than many lenses can actually resolve. Only very high-quality lenses can resolve 60 line pairs per millimeter (LP/mm) or more. This equates to a resolution of 8.4 megapixels for a surface of 23.5×15.7 mm – the dimensions of the popular APS-C sensors found in many DSLRs. Longer zoom lenses can only produce about half this resolution, making it technically fruitless to pack 12 megapixels onto a 6.2×4.6 mm sensor, as is the case in many digital compacts. The only advantage of this kind of pixel overkill is that it distributes lens imperfections between more pixels.

But this isn’t a new problem. Depending on their sensitivity, 35mm films produce resolution of between 40 and about 200 LP/mm, which means that in the analog world, too, the lens is the weakest link in the image production chain. Theoretical film resolutions are only seldom achieved, although increasing resolution does not make analog film any thicker or more difficult to process.



The photoreceptors in the Fujifilm EXR sensor can be switched to work in pairs (outlined in white in the illustration), which helps to reduce image noise for photos taken at high ISO values. The photoreceptors can also be divided into two groups which simultaneously produce two separate images using different shutter speeds. These can then be automatically merged into a single image with increased dynamic range.

As most digital photographers know, digital zooming is not a satisfactory way to compensate for inadequate focal length. It simply enlarges a cropped detail of the image captured by the sensor, creating a photo that is interpolated from only a small portion of the available image data and displays very poor detail. If you really need to enlarge a detail from an image, it is much better to use an image processing program to make your crop, as this usually preserves more detail than the camera's firmware can.

The way DSLRs are constructed makes it impossible to display a preview image on the monitor when the mirror is in its lowered position, and Live View – which displays the scene as it is seen by the image sensor in real time and is a standard feature in most current DSLRs – involves raising the mirror, which in turn makes the viewfinder useless. In studio situations, you can attach your camera directly to a notebook or desktop computer to produce a Live View image on the computer's monitor, a setup known as **tethered shooting**.

The Camera Monitor

The monitor is the most important user/camera interface, but is usually of limited use in daylight and almost no use in bright sunlight. Brighter, more responsive OLED monitors are starting to replace LCDs, but an optical viewfinder is still a good option for keeping your framing accurate. Electronic viewfinders are now starting to catch up with their optical counterparts, and Panasonic significantly raised the bar with the introduction of the Lumix G1 model and its 800 × 600 pixel SVGA viewfinder, a technology that makes it difficult to tell whether you are looking at an electronic version of a scene or reality.

Most camera monitors now offer a resolution of 200,000 pixels or more. Some manufacturers also state monitor resolution in "dots", leading to figures of 900,000 and more, although these have to be divided by three to calculate the true number of red, green and blue (RGB) pixels a monitor contains. More and more cameras are offering built-in tilt/swivel monitors, which help to alleviate reflection problems and make it much easier to shoot from unusual angles without pulling a muscle.

Better cameras display active focus areas, histograms and clipping (under- or overexposure) warnings on the monitor along with the standard preview image and camera settings. Clipping warnings are especially useful in the case of overexposure, as it is impossible to rebuild burned out highlight detail once it has been recorded as part of an image file.

Aside from the constant battle of the megapixels, small image sensors have made previously unthinkable lens geometries an affordable reality. Bridge cameras – the segment between compacts and full-fledged DSLRs – often boast zoom ranges that were unheard of in the analog world. One of the current forerunners in this category is the Fujifilm FinePix HS10 with a 30x zoom range equivalent to a 24-720mm lens on a 35mm camera. The lens is stabilized and has a maximum aperture range of f2.8-f5.6, making handheld shots easy and reliable throughout the entire range. Lenses like this are universal tools that cover just about every conceivable everyday photographic situation, although they do make some compromises concerning overall image quality and distortion characteristics. Analog zoom lenses usually produce inferior image quality compared with fixed focal length lenses. The major advantage of digital images is that most types of anomalies – whether chromatic aberrations, distortion or vignetting – can be digitally corrected after shooting, either in-camera or on a computer.

Ultra-wide-angle lenses are rarely built into or used with cameras that have small sensors, as the negative crop factor has adverse effects on the images they produce.

Shutter Delay and Burst Speed

Consumer-level digital cameras prove that digital technology is not necessarily more powerful than older, mechanical technology. Delays of just tenths of a second – the time it takes a compact camera to meter exposure and select the appropriate camera settings – between pressing the shutter button and the actual exposure are a sure-fire recipe for missing spontaneous snapshots. DSLRs have separate metering sensors, making shutter delay a non-issue for all cameras in this class.

Some "smart" metering modes can also cause significant shutter delay. For example, if you activate smile or face recognition, your camera will appear to do nothing for several moments after you have pressed the shutter button. To effectively reduce shutter delay, switch off all of your camera's automatic systems, including autofocus and automatic exposure metering. You can still meter a shot automatically and then switch to manual metering before dialing in your metered exposure values, and if you are not confident of your own focusing skills, you can use a smaller aperture to ensure that your shot contains sufficient depth of field.

Digital cameras no longer have to transport film between frames, but it still takes time to transfer ever-increasing amounts of image data from the sensor to the memory card after each shot. Many contemporary cameras have large data buffers that can temporarily store several full-resolution im-

ages immediately after shooting, but even the fastest cameras have to take a break if the data buffer is full. Because of the difficulties involved in combining speed with image quality, Nikon offers two versions of its high-end D3 DSLR. The D3H is designed for high shooting speeds (up to nine frames per second continuous), while the D3X has ultra-high resolution and enhanced bit depth for producing extremely high quality images.

Image Stabilizing

This technology is built into most current compact and DSLR cameras and allows you to shoot shake-free, handheld images using shutter speeds that are up to 16 times longer than you could normally use, without producing camera shake. Image stabilizers use gyroscopic sensors that register the movements of the camera (not the subject!) and convert the resulting readings into opposite movements in either special, mobile lens elements or the image sensor itself. Canon, Nikon, Panasonic, Sigma and Tamron lenses use movable lens elements – called **lens shift** technology – to compensate for unwanted camera movement, while Olympus, Pentax, Ricoh and Sony build their anti-shake mechanisms into the camera body and use them to make compensatory movements in the image sensor. The advantage of the latter, which is called **sensor shift** technology, is that it is part of the camera body, doing away with the need to build the technology into every lens.

Nikon uses its own patented Best Shot Selector (BSS) to counteract camera shake by taking a sequence of up to 10 photos at a single press of the shutter button and automatically selecting and saving the sharpest. A less common, software-based method automatically applies motion blur correction to images in the camera.

Some manufacturers describe automatic ISO speed increase functionality as a kind of image stabilization, but this is only a marketing strategy that contradicts the definition of true image stabilization, which is designed to enable you to use longer shutter speeds. Increasing ISO values actually decreases shutter speeds and, as such, does reduce camera shake, but at the price of increased image noise.

ISO Sensitivity Values

Changing the ISO value increases or decreases the strength of the electronic signals from the sensor. Increasing the ISO value is comparable to analog push processing, which artificially increases film speed after shooting. Like analog film, every image sensor has a

fixed basic sensitivity that is determined by its construction and that is usually somewhere between ISO 50 and ISO 200. ISO values are the direct equivalent of analog ASA values, which have completely replaced the older DIN norm for measuring light sensitivity. Back then, 21° DIN equaled 100 ASA. Doubling an ISO (or ASA) value doubles the sensitivity of the medium (or increases the DIN value by 3°). A generally accepted rule of thumb states that an exposure value (EV) of 13 is required to take a “good” photo of an object lit with 20,000 lux (i.e., daylight). This equates to an aperture of f8 combined with a 1/125 second shutter speed, or any combination that produces the same EV, i.e., 1/250 second at f5.6, or 1/500 second at f4.

Increasing your ISO value usually increases the incidence of image noise in the same way that analog push processing increases grain in a finished image. The latest DSLRs allow shooting at ISO speeds of up to 400 or even 800 without producing noticeable noise effects. The small sensors built into most digital compacts are much more susceptible to image noise due to the small size of the individual photoreceptors that make up the sensor.

Image Noise

Noise is the product of random fluctuations in electronic circuits – in our case, in the image sensor’s circuitry – and produces interference that disrupts the useful image data signals. The degree of image noise depends on the temperature of the sensor and its surroundings, but is otherwise fairly constant. The brighter the light that reaches a photoreceptor, the stronger the resulting data signal will be in relation to the constant noise produced by the sensor – i.e., the signal-to-noise ratio will increase while noise becomes less obvious. Photoreceptors with a diameter of 6 µm or more produce virtually no noise at low sensitivity settings, making large sensors with large photoreceptors less noisy than smaller, more densely packed sensors.

In spite of the many comparisons that exist between film grain and digital image noise, the “feel” produced by noise is a very different one. Film grain is random and is often used deliberately as a compositional tool to enhance the mood of an image, whereas digital noise is simply irritating. Many digital cameras have built-in noise reduction circuitry that switches in automatically at high ISO values. Long exposures often suffer from increased noise, called **dark noise**. This can be effectively counteracted by shooting a “dark frame”, a photo of complete darkness taken using the same expo-



A Nikon Mode Dial, showing the settings for P, S, A and M modes, Auto mode and various Scene modes

sure values as the original photo. The noise patterns within the dark frame are subtracted from the image data, producing a cleaner, less noisy image.

Thermal noise caused by high ambient temperatures is more difficult to eliminate. It is usually more effective to switch off any built-in noise reduction features your camera might have and to reduce noise using specialized computer software. “**Hot pixels**” produce similar effects, but are caused by defective pixels rather than electronic noise. They show up either black or white in an image and are relatively easy to remove during shooting if you know their exact coordinates. The camera’s firmware simply replaces them with color values taken from surrounding pixels. Hot pixels can be replaced at the image processing stage too, and some high-end DSLRs even have a feature that allows you to shoot an additional hot pixel image for easy reference later on.

Exposure

Aperture and shutter speed determine how much light reaches the image sensor. “Correct” exposures always allow the same amount of light into the camera, regardless of how brightly a subject is lit, making it necessary to use longer exposure times or wider apertures to photograph dimly lit scenes. This relationship might appear to be trivial, but is not always easy to master. The basic Exposure Value (EV) provides a reference point that can be used to determine the de-

gree to which the amount of incident light has to be reduced to avoid overexposure. The appropriate EV therefore depends mainly on subject brightness, but also on sensor sensitivity if this is not constant. A brightness value of 20,000 lux equates to an EV of 13 at a sensitivity of ISO 100, and doubling the ISO value (or the overall brightness) increases the EV by 1. This increase requires the exposure to be halved, either by increasing the shutter speed or by reducing the aperture. Each EV value can thus be represented by a series of aperture/shutter speed combinations, all of which allow the same amount of light to reach the sensor. An EV of 0 at ISO 100 (21° DIN) equates to an exposure of one second at f1.0, two seconds at f1.4, four seconds at f2 etc. – i.e., pairing either a lot of light with a short exposure or less light with a longer exposure.

Aperture values are the result of dividing the focal length of the lens (f) by the diameter of the opening in the lens, which is why an aperture value of f5.6 is also sometimes written in the form f/5.6. The widest possible aperture of a lens usually equates to the diameter of its front element and is stated using the smallest numerical aperture value the lens

can produce. This value is also often described as the “brightness” of a lens. Doubling the diameter of the lens opening quadruples its size and therefore also quadruples the amount of light entering the camera. This explains the non-linear numbers used to describe apertures, which are based on the square root of 2 (which is 1.414).

Shutter speeds do not require detailed explanation. Both apertures and shutter speeds are nowadays described using standardized scales of values in which each value either halves or doubles the previous value.

Automatic exposure systems are governed by rules and algorithms that can be quite complex. “Normal” through-the-lens (TTL) metering simply measures all light that enters the lens and often leads to overexposure for very bright scenes, like snowscapes, or underexposure for dark scenes, like night shots. The current trend is toward replacing simple TTL metering with center-weighted metering systems, which overweight the objects in the center of the frame when calculating exposure values. Matrix metering is a more precise method that analyzes various input information, including focus settings, from multiple areas within the frame. The camera then com-

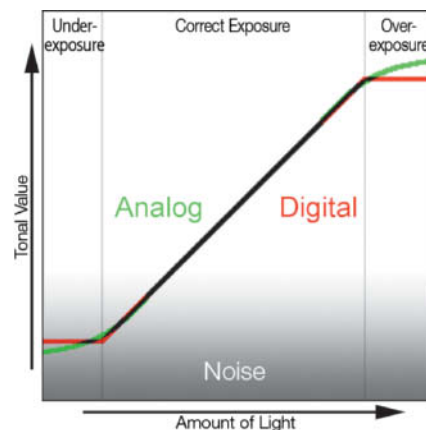


Chart showing the reaction curves for photographic film (in green) and digital image sensors (in red)

Light, Exposure Values, ISO Sensitivity and Aperture/Shutter Speed Combinations

The exposure Value (EV), which depends on how brightly the subject is lit and the ISO sensitivity of the film or image sensor you are using, states the exposure level at which medium darkness (such as that of an 18% gray card) or medium pixel brightness occurs. The value can be achieved using different combinations of apertures and shutter speeds, indicated by the light gray boxes in the table.

For example, a subject lit with 20,000 lux and photographed at ISO 100 (21° DIN) requires an EV of 13 in order to be correctly exposed.

	ISO	25	50	100	200	400	800	1600	3200
Lux	100	3	4	5	6	7	8	9	10
	200	4	5	6	7	8	9	10	11
	500	6	7	8	9	10	11	12	13
	1000	7	8	9	10	11	12	13	14
	2000	8	9	10	11	12	13	14	15
	5000	9	10	11	12	13	14	15	16
	10 000	10	11	12	13	14	15	16	17
	20 000	11	12	13	14	15	16	17	18
	50 000	12	13	14	15	16	17	18	19
	100 000	13	14	15	16	17	18	19	20

Digital cameras have “optimum” aperture/shutter speed combinations for all EVs saved as part of their firmware, indicated by the light orange boxes in the table. Our camera selected 1/250 second and f5.6 for the required EV of 13.

Shutter Speed (in seconds)	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000
Aperture													
1	0	1	2	3	4	5	6	7	8	9	10	11	12
1.4	1	2	3	4	5	6	7	8	9	10	11	12	13
2	2	3	4	5	6	7	8	9	10	11	12	13	14
2.8	3	4	5	6	7	8	9	10	11	12	13	14	15
4	4	5	6	7	8	9	10	11	12	13	14	15	16
5.6	5	6	7	8	9	10	11	12	13	14	15	16	17
8	6	7	8	9	10	11	12	13	14	15	16	17	18
11	7	8	9	10	11	12	13	14	15	16	17	18	19
16	8	9	10	11	12	13	14	15	16	17	18	19	20
22	9	10	11	12	13	14	15	16	17	18	19	20	21

Histograms

Most modern cameras are capable of displaying the distribution of tonal values in a photo as a histogram, either during the Live View preview or immediately after an image has been recorded. A histogram does not represent the real distribution of tonal value within the subject, but rather that of the version captured by the camera's sensor. This helps you to judge whether highlight or shadow detail has been clipped. If the histogram curve is shaped like a mountain, your image is probably well exposed. If the curve displays sudden drop-offs at either end, you are most likely looking at an under- or overexposed image.

The total width of the curve represents the dynamic range of your camera, and a subject can have a larger, smaller or similar dynamic range.

Subject contrast the same as camera dynamic range:

This is the ideal situation. The histogram curve fits exactly into the histogram window, indicating perfect exposure with no clipped highlights or shadows. Here, the camera's



The tonal values in an image can be allocated to zones according to a system invented by Ansel Adams that uses exposure and development to produce the best possible balance of zones in the finished image

own dynamic range is used to the maximum possible extent – the darkest image details will appear almost black, while the brightest parts appear to be almost pure white. The individual peaks and troughs of the histogram curve are unimportant. In darker, low-key images, more tonal values will be located in the left-hand half of the curve. A majority of the values will be higher for brighter images.

Subject contrast greater than camera dynamic range:

In this case, it is impossible to expose the image without clipping either the shadows or the highlights, or both. You'll have to de-

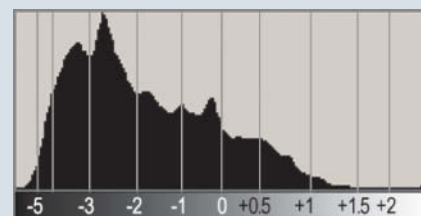


Digital cameras allocate the tonal values captured by the sensor to a scale of 256 values – equivalent to 256 Adams-style zones. A histogram displays the number of pixels for each zone in the captured image. Here too, the aim of the exercise is to produce a balanced image that reflects the nature of the subject. A high-key (i.e., bright) image like the one here contains a great many pixels at the bright end of the scale.

cide which tonal values are more important to the overall look of the image and expose accordingly. If the shadows are more important, you will need to use a higher exposure value and simply accept that some highlight detail will be lost. Remember, a few bright white highlights can actually improve the overall look of an image.

Subject contrast less than camera dynamic range:

If the histogram curve displays gaps at both ends of the scale, there will be no really dark shadows or bright highlights in the finished image, which will appear dull and lifeless if contrast isn't artificially increased. You can increase image contrast by using an image processing program to stretch the histogram curve to fit the scale precisely. Some cameras have built-in functionality for achieving the same effect and can actually produce better results than subsequent JPEG processing if the process is applied to RAW image data. RAW image data can also be processed just as effectively later.



In a darker image, the majority of the pixel values are located to the left of the curve. The "medium bright" (or 18 percent gray) pixels are located in the center of the curve due to the logarithmic nature of human vision. The relative exposure values within the curve are indicated along the horizontal axis. Deliberate overexposure of +2.5 EV would make a medium gray tone look pure white.

compares the current situation with a database of saved situations and selects appropriate settings from a range of preset values. The latest cameras are capable of identifying important details, such as faces, within the frame and select settings that optimize exposure for that detail.

If you still prefer to make your own measurements and settings, spot metering is your best option. Spot metering enables you to

meter light precisely for extremely small details covered by a narrow angle of view – usually in the center of the frame. If you use spot metering to measure exposure for a standardized 18 percent gray surface, you will usually end up with an acceptable exposure for the whole frame. The 18 percent reflective value is generally perceived as "averagely bright" by the human eye and has a similar brightness value to a green lawn or the palm

of the photographer's hand when it is held in front of a lens. If you use a reference value to calculate exposure, it is important that the reference surface is lit by the same light source as your subject. If this is not the case, or no appropriate reference object is available, a useful standard method is to meter for the brightest point in the frame (except, of course, the light source itself) and to expose your shot using the metered value plus an ex-



Well-formed circles of confusion, or *bokeh*, as they are widely known, are a welcome addition to many compositions. It is a look that cannot be achieved using soft focus effects alone (see ‘The Beauty of Blur’ in issue 2)

posure compensation value between +2 and +2.5 EV.

This spot metering method is often prevents unwanted overexposure more effectively than either gray card or automatic exposure metering. A separate exposure lock button (often labeled AE-L) is essential, as it allows you to save your metered values while reframing and composing your scene. Otherwise, pressing the shutter button halfway (especially in compact cameras) locks not only the current exposure settings, but also the focus setting, making accurate focusing impossible if you reframe your subject.

The particular combination of exposure values that the camera selects depends on the metering mode you are using. Most mid-range and high-end cameras offer four main metering modes:

Programmed Auto (P): This is the simplest, but not always the best mode to use, as the camera uses preset combinations of aperture and shutter speed values (see the table below) that are not always appropriate to the situation at hand.

Aperture Priority (A): Here, the photographer selects the desired aperture manually and leaves selection of the appropriate shutter speed to the camera, which keeps the overall EV constant.

Shutter Priority (S): In this case, the photographer selects the shutter speed manually and leaves selection of the aperture to the camera. This mode is especially useful for sports photography or when photographing other fast-moving subjects.

Manual (M): The photographer selects both aperture and shutter speed manually, with or without assistance from the camera’s built-in light meter. This mode is useful if you want to make longer exposures than the camera normally allows – when you are shooting at night, for example.

Im Modus „Programmautomatik“ kann zudem das gewählte Motivprogramm die Belichtungseinstellungen beeinflussen. Beim Motiv „Sport“ wird zum Beispiel die Präferenz auf kurze Belichtungszeiten gelegt, beim Motiv „Landschaft“ auf große Schärfentiefe, das heißt kleinere Blendenöffnung.

Scene modes also influence the camera’s exposure settings. For example, Sports mode will always give preference to shorter shutter speeds, while Landscape mode will always attempt to produce the greatest possible depth of field (i.e., the smallest possible aperture). But no matter how sophisticated your camera’s systems are or how much experience you have, mistakes can always occur, and it can be helpful to shoot a **bracketing sequence** as a backup. This feature enables the camera to shoot multiple images of the same scene using differing aperture and shutter speed values at intervals chosen by the photographer. You can shoot the individual shots in a bracketing sequence either singly or at a single press of the shutter-button if you combine the function with continuous shooting mode. You can also use bracketed shots to shoot high dynamic range (HDR) photos without a tripod, although some cameras don’t allow you to set the necessary bracketing intervals of 1 or 2 EV. Many cameras limit bracketing intervals to a maximum of 3 EV.

Dynamic Range

Dynamic range describes the range of tonal values that an image sensor can capture. The lowest values lie just above the level of ambient image noise, while the highest values lie just below the saturation level of each photoreceptor. The dynamic range of most digital compacts covers about 8 EV, while most quality DSLRs, with their larger image sensors, can capture 9 or 10 EV. The

greater signal-to-noise ratio provided by large image sensors is an advantage here, as dynamic range can only be extended downward unless interpolation tricks are used. The range of tonal values between midtones and highlights is physically limited to about 2.5 EV, which means that most of the available tones lie within the darker part of the scale. The human eye, too, is more sensitive to tonal differences in shadows.

Eight EV is a fairly limited range and represents contrast of 1:256 (i.e., 2^8). In nature, this kind of range is present even in dull weather, and bright, sunny weather gives subjects a much higher range of contrast, especially when important details are located in the shade. In situations like this you have to decide which part of the tonal scale is more important to the effect you want to achieve and whether to expose to preserve shadow or highlight detail. Exposing for shadow detail nearly always produces washed out highlights and clouds that blend in with very bright sky.

Additional image noise also limits the degree to which you can safely brighten shadows during image processing. The problem is compounded in the case of 8-bit JPEG images, as these have a limited range of shadow values, which start to look very similar if they are brightened artificially. You can usually achieve more effective results if you brighten the shadows in RAW images, because they contain a greater range of shadow values, but the only sure-fire way to achieve real improvements is to shoot sequences of images at different exposures and merge them to produce images with artificially enhanced contrast. This technique is known in specialist circles as HDR or DRI.

Improvements in technology are sure to make enhanced dynamic range a standard feature of future camera generations. Features such as Nikon’s D-Lighting already go a long way toward improving JPEG detail by reducing overall exposure and brightening shadows in a single processing step. *D-Lighting* can also be applied to RAW image data, producing even better results than it does when applied to JPEG images. Applied in-camera, the *D-Lighting* effect takes longer to apply than equivalent image processing steps but has the advantage that it can be applied on the fly.

Fujifilm uses special sensor chips to increase camera dynamic range. The Super CCD SR sensor combines two different sizes of photoreceptors and uses the smaller cells to record highlight detail when the larger, more light-sensitive cells have reached saturation point. Fuji’s EXR sensor technology in-



A selection of white balance preset icons:



Sunlight, Cloudy, Fluorescent, Incandescent, Flash, Manual



tegrates HDR functionality directly into the camera. The sensor's double photoreceptors record either a single high-resolution, 12-megapixel image, or two 6-megapixel images with different exposure settings that are automatically merged into a single HDR image.

Focus

Strictly speaking, the only way to take perfectly sharp photos is to use perfectly flat lenses. Theoretically, the light rays that emanate from every point on an object have to meet at a single point on the image plane. However, at certain distance settings, light rays that emanate from closer or more distant points meet at points that are either in front of or beyond the image plane and cannot

therefore appear as focused points on the image plane itself. Instead, they appear as small, blurred "circles of confusion". If these circles are small enough – i.e., smaller than the diameter of a single sensor cell – the human eye doesn't perceive them as being out of focus. Larger circles of confusion are also perceived as acceptably sharp, which makes a certain area in front of and beyond the subject that is being focused on part of the in-focus area within an image. This area is a photo's **depth of field**.

The range of this depth depends on both the aperture and the reproduction ratio and is bounded by a near point and a far point. The distances between the **near and far points** and the **point of focus** are similar only for close subject distances. In extreme cases, the far point is located at infinity.

The focal distance at which this is the case is called the **hyperfocal distance**, and the near point is exactly half the hyperfocal distance. You can find detailed explanations and a tool for calculating depth of field at www.dofmaster.com.

Circles of confusion are not, in fact, homogenous discs, and actually take the form of blurred circles that are the same shape as the aperture blades built into the lens. Circles of confusion have sharp centers and produce very different effects from conventional soft focus techniques. For this reason, circles of confusion that are larger than the individual photoreceptors in a camera's sensor are not always considered to be un-aesthetic. The maximum acceptable diameter for circles of confusion, Z, depends on what camera format you are using. The generally accepted value for the 35mm format is 0.03 mm. This decreases proportionately

for cameras with smaller sensors. The common 2/3" sensor format has a Z value of 0.008 mm.

Different cameras employ various auto-focusing methods. The simplest systems assess subject contrast and adjust focus in one direction or the other until maximum contrast is achieved. Because the camera doesn't know which direction it needs to look in, this method sometimes makes focusing quite slow, and is therefore only usually used in consumer-level cameras. In contrast, the infrared distance measurement systems used in some DSLRs and compacts are very fast.

The fastest and most precise system, triangulation, uses two sensors mounted beneath the camera's mirror to measure the angle of incidence at the camera of light emanating from the subject.

In addition to the traditional focus area in the center of the viewfinder, contemporary cameras have multiple focus areas arranged throughout the image frame which can be selected either manually by the user or automatically according to the subject depth measured by the camera's systems. This type of system is simple and effective as long as you don't want to use unusual focusing effects like deliberately blurred foregrounds, which most cameras simply cannot handle automatically. Continuous autofocus mode constantly updates the subject distance and is even capable of predicting a subject's movements based on its previous behavior. Some systems are also able to track subjects that the system has detected and activate the appropriate focus area when the subject moves from the center to the edge of the frame. Face recognition is the most sophisti-



Image processing programs often include tools and filters for recreating historical photo looks. These are some of the effects you can produce using *Paint Shop Pro's* Time Machine filter.

cated of the currently available focus features, and is a great help if you shoot a lot of portraits.

White Balance

A sheet of white paper appears white to the human eye, regardless of the color temperature of the light source used to illuminate it. However, photographic film and image sensors do not automatically compensate for different lighting the way our eyes do, and reproduce colors exactly as they are in nature. This often leads to photos containing **color casts**. In analog times, corrections to color casts were made during processing at a lab.

Subsequent corrections to the color temperature (a process that just about every image processing program is capable of) further reduces the already limited tonal range of digital images. For this reason, it is advantageous to select the correct white balance setting at the shooting stage, as video cameras have done automatically for decades. White balance mechanisms assume that the brightest parts of an image are white and measure the differences between these and other parts of the frame. The values thus measured are then used to correct the overall color balance.

Alternatively, you can directly measure the color temperature of the ambient light in your scene using either the camera's built-in systems or a separate meter. Using automatic white balance settings always involves the risk of not capturing the mood of a scene exactly the way you see it. Here, you can also

choose from a range of preset lighting situations that are programmed into the camera's firmware. Some cameras also allow you to enter a specific Kelvin (K) color temperature value.

The most precise, but also the most complex, way to measure color temperature is by hand, using a special shooting mode to photograph a white surface lit by the same light as your subject and applying the resulting color temperature value to your photos. White balance values captured this way can also be stored for use during subsequent sessions. Some cameras save white balance values on the memory card, while others save them in internal memory to save card space.

The white balance values measured by the camera are saved with, but not yet applied to, RAW images. You can apply the metered value or a value of your own later using a RAW editor. It is much easier to judge the effects of changes on a computer than it is on the camera's own monitor.

Color Depth and Color Spaces

High-end cameras digitize images using 12- or 14-bit color depth. 14-bit color depth means that the camera can save up to 16,384 different tonal values for each color, compared to the 256 different values that 8-bit (JPEG) color depth can record. Only RAW formats allow you to use this extra precision at the output stage. Reduced color depth doesn't necessarily mean poor quality images

if the available tonal range is appropriately distributed, and 8-bit color depth is usually sufficient to produce acceptable quality print or monitor output anyway.

The tricky part of converting RAW image data for 8-bit output lies in distributing the RAW tonal values within the 8-bit image so that all the important subject details are preserved. Professional photographers nearly always perform their RAW development using a high-end computer. State-of-the-art camera technology has taken a lot of the guesswork and quality loss out of in-camera JPEG image production, so it is not always necessary to go to the extra trouble of converting your own RAW images. Detailed RAW conversion is really only necessary if you need to squeeze the very last drop of dynamic range or sharpness out of your image data.

Your choice of color space will also make a difference to color nuances in your images. If your camera has it, the AdobeRGB color space offers a greater range of tones than sRGB. Nowadays, quality printers and monitors are capable of reproducing all colors in the AdobeRGB space. Most consumer-level photo labs and home PC photo workflows are configured to use the sRGB color space, although we hope that this situation will soon be a thing of the past and that sRGB will be relegated to the role of a low-quality alternative.

Filters and Camera Profiles

Unlike analog film, digital image sensors are not sensitive to ultraviolet light. They are, however, sensitive to infrared light and usually have built-in infrared blocking filters combined with the low pass (anti-aliasing) filters that are used to eliminate moiré effects. Moiré effects occur when grid patterns in subjects are superimposed on the pattern made by the photoreceptors in the image sensor, causing unwanted color interference. Some high-end cameras and camera backs allow the user to switch off their built-in infrared filters. Instructions for removing the filters from some other cameras are available on the Internet. If you want to take infrared photos using a digital camera, you'll also need to reduce the amount of visible light entering the camera using an accessory infrared filter.

Other colored filters that were used in the analog world for correcting color casts or increasing black-and-white contrast are no longer viable for use in a digital context. Most cameras have a range of built-in digital color filters that can be applied and adjusted at the push of a button either before shooting or later, during image processing.

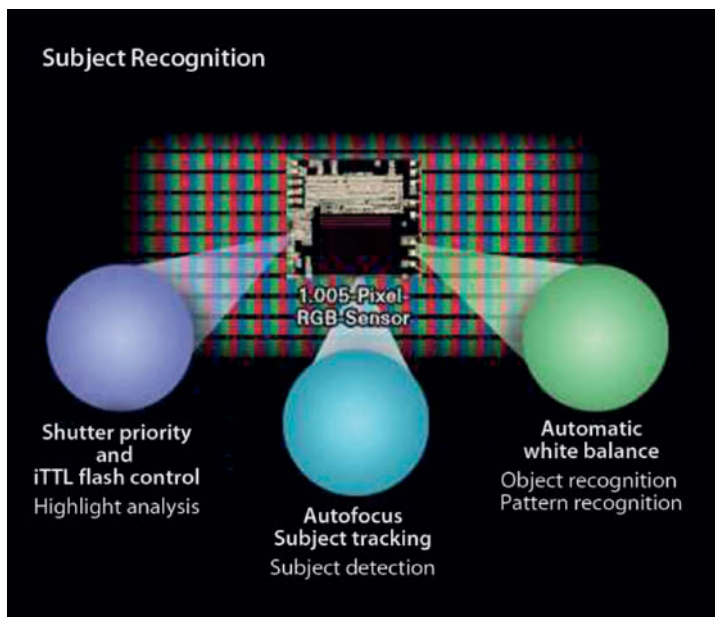


Photo: Nikon

The 1005-pixel RGB sensor built into Nikon's D3 series cameras is an addition to the system's 51 focus areas that allows the camera to track focus even if the subject is temporarily out of sight

Geotagging

GPS receivers are now so small that they can be easily built into compact digital cameras, making it simple to save the geographic coordinates of a subject and even the compass point the camera was facing in a photo's Exif metadata. This functionality makes it easy to link photos with various types of electronic maps, opening up new ways of creating travel reports and route descriptions for your friends.

GPS receivers are also available as bolt-on accessories and some cameras are capable of automatically including geodata in image metadata. You can also look up geodata later on the Internet and add it manually to your image metadata.

Smart Functionality

An old photographers' joke talks about the mythical bell that rings in your camera when you approach a great subject. In their attempt to use advances in digital technology to turn this myth into reality, camera manufacturers offer a wide range of "smart" camera features, including:

Face recognition: Here, the camera automatically recognizes faces and focuses on them. If the frame contains a group of faces, the camera lets you decide which is the main subject. If the current shooting parameters allow it, face recognition systems also adjust depth of field to suit the subject. Further refinements in this area include smile and blink recognition. These types of features can severely limit the photographer's freedom, as the camera only allows the shutter to be released when its preprogrammed "ideal" shooting parameters have been met. Some face recognition systems also cause considerable shutter delay, making it difficult to shoot spontaneous snapshots, but the feature nevertheless has its advantages if used carefully.

Subject recognition: Camera manufacturers distinguish between scene modes and subject recognition. Scene modes simply suggest known, useful combinations of shutter speed, aperture and ISO speed for various types of subject. Some camera systems automatically select the appropriate scene mode, and can even automatically select macro mode if the subject is very close to the camera.

The latest object recognition systems take the technology a step further and assess the actual nature of a detected subject, making it possible to separate the subject from its surroundings and use targeted focus tracking to follow it. Nikon's object recognition system



Nikon's Coolpix P6000 was one of the first digital compact cameras to include a built-in GPS receiver

uses an additional 1005-pixel RGB sensor to gather distance and color information and can track focus for various types of subjects, even if they are moving in front of changing background details. Digital compacts use all of their sensor photoreceptors to analyze their subjects anyway, making some high-end compacts better at recognizing subjects than their DSLR counterparts. Maybe in future we will see DSLRs with two separate sensors – a high-resolution one located behind the semi-transparent mirror for recording image data, and another, with monitor-level resolution, for subject analysis and Live View display.

Beauty mode: This type of functionality enables photographers to manipulate portrait images in ways that used to be the preserve of professional graphic artists. Wrinkle smoothing, freckle reduction and skin color optimization are just some of the aspects of a portrait that can now be adjusted quickly and easily during shooting. The Olympus Beauty Fix feature even allows you to enlarge and brighten your subject's eyes in the camera. Such techniques are used routinely during post-processing in the field of fashion photography, but turning them into automatic camera features raises questions about the authenticity of the results they produce. Image manipulation at the press of a button transfers the responsibility for image alteration subtly but unavoidably from the pho-

tographer to the camera. We are used to cameras producing raw, unprocessed representations of reality, but cameras that deliberately "lie" add a new element to the mix that I fear we will simply have to get used to.

The rapid progress being made in object and face recognition technology also raises privacy questions, and it is only a matter of time before cameras become capable of recognizing individuals using technology that is already standard equipment for the police and secret services in many countries. Such features are undeniably useful and the idea that cameras will soon be able to recognize specific buildings or monuments using GPS coordinates or links to Internet photo databases is no longer confined to the realms of fantasy. It is also conceivable that such systems could be extended to help us recognize specific plants or animals. Never again will we have to rack our brains about what we have photographed or where we photographed it.

Some image processing programs already include face recognition functionality that allows the user to search for images that contain faces similar to ones that are already saved. We mustn't lose track of the ethical questions raised by technological progress, and society needs to find the right compromise between too much freedom of information and over-zealous censoring of genuinely useful tools and systems. (ae/rez) **ct**



The richly detailed reflection of the surroundings captures our attention so that we are barely aware that the bubble is about to burst

Richard Heeks

Bursting **Bubbles**

With the simplest of materials and a great deal of patience, Richard Heeks photographed bubbles in the act of disappearing. Here he lets *c't Digital Photography* readers in on the story behind these spectacular images – and reveals that anyone can do the same using a DSLR or EVIL camera.



The right half of the bubble has already burst but the left half is still shimmering with intriguing streaks of color (Nikon D90, 70mm at f5, 1/550 s at ISO 800)

Timing was, purely and simply, left to chance; our well-rehearsed teamwork was all that was required.

Don't even think about taking photos of bubbles unless the air is almost completely still. Even then, I still had to take about 10,000 shots in order to get five or six really good images. My Nikon D90 shoots at 4.5 frames per second, which I exploited to the max. A bubble bursts within 1/200 second, so you need to use a shutter speed of 1/500 second or less. I generally set the ISO value to 800, and combined this with an aperture of f5.8.

Bubbles photograph best in sunlight, and it is vital to have a dark, shadowy background so that the reflected environment shows up as clearly as possible against it. I used a 70mm lens to bring out the best in our reflections. The transparent environment and the reflections make it difficult to focus, so manual focusing is essential. (jr) **ct**



The hand and the last intact fragment of bubble are slightly out of focus, further highlighting the explosive action

While watching my nieces play with soap bubbles in the summer of 2008, I suddenly realized how beautiful these fragile spheres are, how they continually change the colors around them and how their surfaces reflect their surroundings. For weeks afterward, I played with soap bubble photography, trying to understand these reflections and capture them with my camera.

A year later, still only a beginner, I happened to shoot a bubble just as it was bursting. I didn't even know that was possible! My wife was then roped in to help and spent two weeks popping bubbles with her finger at my command. With a little practice, we managed to synchronize everything really well and the photographs we produced were so spectacular that they attracted worldwide attention and ended up being published in various places, including www.flickr.com/photos/11164709@N06/sets/72157623083082333/.

CONTACT INFO

ct Digital Photography

Editorial Office

Phone: +49 511 53 52-300
Fax: +49 511 53 52-417
Internet: www.ct-digiphoto.com

Contact: editor@ct-digiphoto.com

Editor: Dr. Juergen Rink (jr)

Coordination & Localization: Jeremy Cloot

Translation & Proofreading:

Jeremy Cloot, Claire Loftus Nelson

Contributing Editors: Dr. Adolf Ebeling (ae), Jobst-H. Kehrhahn (keh), André Kramer (akr), Angela Meyer (anm), Peter Nonhoff-Arps (pen), Reinhold Zobel (rez)

Authors: Alexander Altmann, Ralph Altmann, Reinhard Eisele, Richard Heeks, Rolf Hempel, Klaus Peeck, Thomas Saur

Assistants: Susanne Coelle, Erich Kramer, Tim Rittmeier, Sebastian Seck, Christopher Traenkman, Martin Triadan

DTP Production: Wolfgang Otto (Director), Juergen Gonnermann, Joerg Gottschalk, Dirk Wollschlaeger

Art Direction and Cover Design: Thomas Saur

Layout: Hea-Kyoung Kim

Photography: Martin Klauss, Andreas Wodrich

Cover Image Production: Thomas Saur (www.tsamedien.de)

DVD Production: Klaus Ditze, Nicole Tiemann

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Non-executive Director: Beate Gerold

Publishing Director: Dr. Alfons Schraeder

Advertising Director: Udo Elsner (+49 511 53 52-222)

Advertising Coordinator: Simon Tiebel (+49 511 53 52-890)

Sales and Marketing Director: Mark A. Cano

(+49 511 53 52-299)

Team Leader Production: Bianca Nagel

International Sales and Customer Service

E-Mail: r.mass@ct-digiphoto.com

(+49 511 53 52-226)

U.S. Sales and Customer Service

Rocky Nook, Inc.

26 W Mission Street #3

Santa Barbara, CA 93101, U.S.A.

Phone: 1-805-687-8727

Toll-free: 1-866-687-1118

Fax: 1-805-687-2204

E-Mail: ct@rockynook.com

Retail Sales:

Linux New Media AG

Putzbrunner Str. 71

81739 Munich

Germany

In cooperation with

Rocky Nook, Inc.
26 W Mission Street #3
Santa Barbara, CA 93101
U.S.A.

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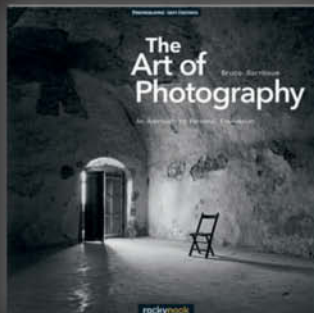
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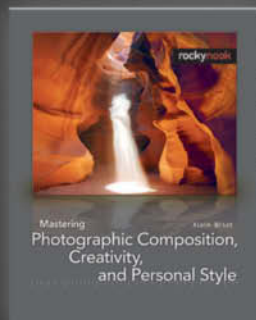
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