Langford's ADVANCED PHOTOGRAPHY

7th EDITION

The guide for aspiring photographers

Michael Langford & Efthimia Bilissi

Contributors: Elizabeth Allen, Andy Golding, Hani Muammar, Sophie Triantaphillidou

Focal Press

Langford's ADVANCED PHOTOGRAPHY LANGFORD

Langford's Advanced Photography

Seventh Edition

Langford's Advanced Photography

Seventh Edition

Michael Langford FBIPP, HonFRPS
Royal College of Art, London

Efthimia Bilissi MSc PhD AIS ARPS
Senior Lecturer
University of Westminster, London

Contributors
Elizabeth Allen BSc MSc
Course Leader BSc (Hons) Photography and Digital Imaging
University of Westminster, London

Andy Golding
Head of Department of Photography and Film
University of Westminster, London

Hani Muammar BSc MSc PhD MIET
Senior Scientist
Kodak European Research

Sophie Triantaphillidou BSc PhD ASIS FRPS
Leader Imaging Technology Research Group
University of Westminster, London

ELSEVIER

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

Focal Press is an imprint of Elsevier

Focal Press

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

First published 1969
Second edition 1972
Third edition 1974
Fourth edition 1980
Fifth edition 1989
Reprinted 1992, 1993, 1994, 1995
Sixth edition 1998
Reprinted 1999, 2001, 2003, 2004, 2005, 2006
Seventh edition 2008

British Library Cataloguing in Publication Data
Langford, Michael John, 1933–
Langford's advanced photography. – 7th ed.
1. Photography
I. Title II. Bilissi, Efthimia III. Langford, Michael John, 1933–. A dvanced photography
771

Library of Congress Number: 2007938571

ISBN: 978-0-240-52038-4

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

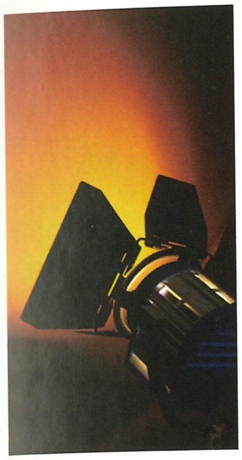
Typeset by Charon Tec Ltd (A Macmillan Company), Chennai, India
www.charontec.com

Printed and bound in Slovenia
08 09 10 11 11 10 9 8 7 6 5 4 3 2 1

Contents

CONTENTS

7 Lighting control 129



8 Tone control 156

loading film. Fitting a hood of correct diameter will reduce the risk of something getting in front of the lens.

Remember the value of having an instant-picture back, to allow you to confirm visually that lens and body are working correctly – plus checking lighting, exposure and composition – at any time during a shoot. Some professional photographers habitually expose one instant picture at the beginning and another at the end of every assignment, as insurance. It is also a good idea to carry another complete camera (a 35 mm SLR, for example) as emergency back-up.

The digital revolution

The first patents for devices capturing images electronically were filed as far back as 1973. Kodak created a prototype digital camera in 1975 using a charge-coupled device (CCD), recording black and white images on to digital cassette tape; however it was built to test the feasibility of digital capture using solid state sensors, rather than as a camera for manufacture (due to it's bulky size and a weight of nearly 3.6 kg). It was not until 1981 that Sony developed a camera using a CCD, suitable to be hand-held and available to the consumer. The birth of digital still cameras as we know them today happened in 1988, when Fuji showcased their camera, the DS-1P, at Photokina. Early digital formats could not compete with their film equivalents in terms of cost or quality; digital cameras as a practical option for consumers were not really available until the mid-1990s. Since then the digital market and technologies have grown exponentially.

The move to digital imaging by many photographers has involved a preceding step via 'hybrid' imaging – that is, capture on film followed by digitization using a scanner. However, in the last ten years, huge advances in sensor technology, computing capabilities and the widespread adoption of broadband (ADSL) Internet connection by the consumer have meant that digital imaging has finally arrived. For example, most households in Britain now own at least one computer and the majority of new mobile phones have a built-in digital camera. The digital camera market has therefore been advanced by the consumer market and of course the widespread use of imaging on the Internet.

Immediate results and the ability to easily manipulate, store and transmit images have become a priority in many disciplines, with some sacrifice in the quality that we expect in our images. In the professional market there have also been compromises between versatility of systems and image quality, but progress towards the uptake of entirely digital systems has been somewhat slower. In some types of photography image quality is still more important than speedy processing and the lack of equipment available in larger formats has meant that film-based systems are still common. Sports photography and photojournalism, however, have embraced a predominantly digital workflow from capture to output.

The image sensor

Instead of exposing onto silver halide coated film, currently the majority of digital cameras contain one of two types of light sensitive array, either a charge-coupled device, known as a CCD, which is common in earlier digital cameras, or fast overtaking it, the complementary metal-oxide semiconductor or CMOS image sensor. The sensor is in the same position as the film in an analogue camera. Many of the key external features of digital and film cameras are similar, but digital cameras have a whole other layer of complexity in terms of user controls in the camera software.

Both types of digital image sensor are based on the same material, silicon, which when 'doped' with small amounts of other elements, can be made sensitive to light. When exposed to light, it produces a small amount of electrical charge proportional to the amount of light falling on it, which is stored, transported off the sensor, converted into a stream of binary digits (1's or 0's, hence the name 'digital imaging'), and written into a digital image file. The process is a complex one, and the structure and operation of the sensor is covered in more detail in Chapter 6. There are many fundamental differences between film-based and digital imaging, not least that where a frame of film both captures and stores the image, and is therefore not reusable, a digital sensor captures the image, but it is then transported away and stored as an image 'file' somewhere off the chip. Theoretically, if an image file is not compressed and is continually copied and migrated across different media, it is permanent and can be reproduced as many times as required, without any degradation in quality.

Sampled images

Another key difference between digital and analogue imaging is the fact that the digital image is captured across a regular grid of pixels (Picture Elements). Each pixel is an individual image-sensing element, which produces a response based on the average amount of light falling on it. Where film 'grains' are distributed randomly through a film emulsion and overlap each other to create the impression of continuous tones, pixels are non-overlapping and if a digital image is magnified, individual pixels will become very evident. Digital images are a *discrete representation*. This is further accentuated by the fact that pixels are not only discrete units across the spatial dimensions of the image, but that they can only take certain values and are solid blocks of colour. The process of allocating a continuous input range of tone and colour to a discrete output range which changes in steps, is known as *quantization* (see Figure 2.12). The whole pixel will be the same colour, regardless of the fact that the light falling on it in the original scene may have varied across the pixel area.

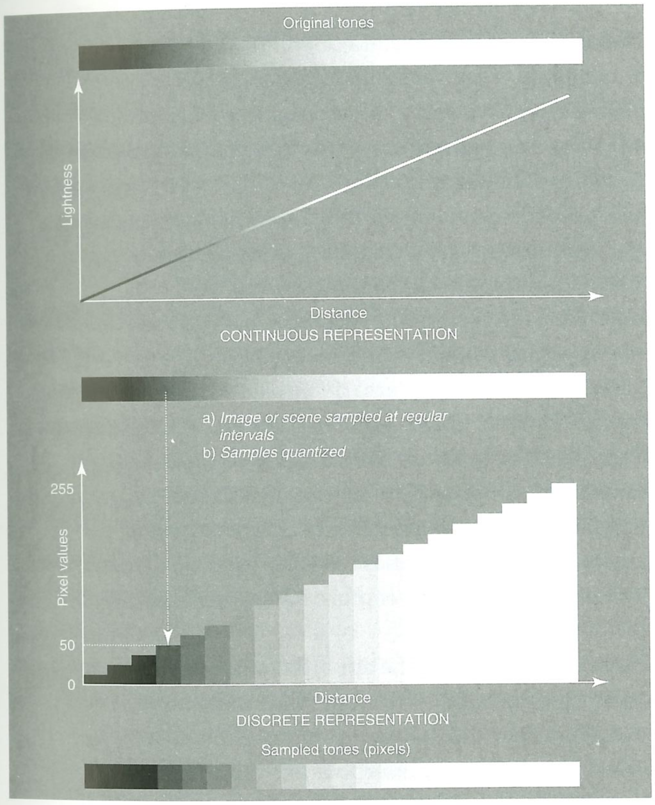


Figure 2.12 Sampling and quantization in a digital image: (a) The image is spatially sampled into a grid of discrete pixels; (b) The continuous colour range from the original scene is quantized into a limited set of discrete levels, based on the bit depth of the image.

A digital image is therefore 'sampled' both across its physical dimensions and in terms of its colour values. The stepped changes in colour values and the non-overlapping nature of the pixels are limiting factors in the quality and resolution of a digital image. The spatial sampling rate is determined by the physical dimensions of the sensor. The quantization levels depend upon the sensitivity of the sensor, analogue to digital conversion, image processing in the capture device and ultimately on the output file format.

Resolution in digital imaging

Resolution is the capability of an imaging system to distinguish between two adjacent points in an image and is a measure of the detail-recording ability of a system. It defines how sharp your images will appear and what level of fine detail will be represented. In any imaging system this is affected by every component through which light passes; in a film-based system the lens and the film will be the key factors, but anything placed over the lens or sensor, such as a filter, may also affect it. It is usually the resolution of the image sensor that is the ultimate limiting factor, which is why film grain is important, although a poor quality lens, as any photographer knows, is a primary cause of loss of sharpness. There are a number of measures of resolution, but two commonly used and covered in more detail in the chapters on lenses and film are *resolving power* and *Modulation Transfer Function (MTF)*.

Where resolution in traditional film-based imaging is well-defined, the different ways in which the term is used and its range of meanings when referring to digital systems can be confusing. It is helpful to understand these differences and to be clear about what resolution means at different stages in the imaging chain. You will see the term explained and used in different contexts throughout this book, but to summarize.

Fundamentally, digital images do not have an absolute resolution, but a number of pixels. The level of detail that is represented will depend upon how this number of pixels are captured or viewed. Therefore, image resolution is often quoted in pixel numbers, calculated by number of rows × number of columns. It may be referred to in terms of *megapixels*, a megapixel being a million pixels; this is a value often quoted by digital camera manufacturers.

At different stages in the imaging chain, resolution may also be measured as a function of distance. Scanner or monitor resolution, for example, may be quoted in terms of numbers of pixels per inch (ppi) and printers are often specified in terms of dots per inch (dpi). The combinations of these different resolutions in the output image determine the final image quality and also output image size. These relationships are examined in more detail in the chapter on digital imaging systems. When quoted by manufacturers of these devices, they will usually quote the upper limit for that device, although it will be possible to capture and output images at a range of resolutions below this.

A clever trick that manufacturers often use to enhance the apparent characteristics of their devices is to quote *interpolated resolution*. This applies to cameras and scanners. The actual (or *optical*) resolution of a device is defined by the number of individual elements and their spacing; however it is possible to rescale an image by interpolating values between the actual values, in effect creating false pixels. The visual effects of this are a slight blurring of the image, because the interpolation process averages adjacent pixels values to create the new pixels.

In cameras too, the *effective resolution* may be quoted, although manufacturers may not identify it as anything other than resolution. Again, this is a form of interpolated resolution, but refers in this case to the fact that in the majority of cameras, the sensor is filtered, so that each pixel captures only one colour, usually red, green or blue. To obtain the other colour values at each pixel in the captured RGB image, adjacent pixels of each colour are used and the missing values interpolated. As with all interpolation there is an associated blurring and loss of quality. There is an exception, however: in the last few years, a new sensor, the Foveon™ chip, has been developed, which captures colour at different depths in the sensor and therefore captures all three RGB values at every pixel. This sensor, however, is only available in a few cameras currently on the market, so for the majority, effective resolution still applies.

How many pixels?

When buying a digital camera, resolution is a primary consideration, and a key factor in image quality, however the previous discussion indicates the confusion around the subject. The highest number of megapixels does not necessarily represent the highest quality or automatically mean that the largest level of detail will be reproduced. Other factors are involved as well.

The pixel *pitch*, which is the centre-to-centre distance between pixels and relates to the overall pixel size, is important in determining the maximum level of detail that the system is able to reproduce. Tied up with this however, is the imaging area of each pixel, which in some cameras may be as low as 20%, due to the inclusion of other components and wiring at each pixel and channels in between imaging areas. Also, the pixel shape; whether there are *microlenses* above each pixel to focus and maximize the light captured; even the interpolation algorithms used in calculating missing colour values, which vary between manufacturers, these will have an effect on final image resolution. These factors combine to influence the shape of the sensor's MTF and it is this that is a far better indicator of how well a camera will perform. The quality of the lens must additionally be taken into account. Finally, and really important, is the pixel size relative to the overall size of the imaging area on the sensor.

What the above discussion highlights is the complicated nature of resolution as a measure of image quality in digital cameras. Do not make a choice based solely on the number of megapixels. Make informed decisions instead, based on results from technical reviews and from your own observations through testing out different camera models. You need to decide beforehand how you want to use the camera, for what type of subjects, what type of photography and what type of output.

Bearing all this in mind, it is still useful to have an idea of the physical size of output images that different sensor resolutions will produce. Print resolution requirements are much greater than those for screen images. Although it is now widely accepted that images of adequate quality can be printed at 240 dpi, or perhaps even lower, a resolution of 300 dpi is commonly given as required output for high-quality prints. Some picture libraries and agencies may, instead of specifying required image size in terms of output resolution and dimensions, state a required file size instead. It is important to note that this is *uncompressed* file size. It is also necessary to identify the bit depth being specified as this will have an influence on file size. Figure 2.13 provides some examples for printed output.

INPUT: CMOS or CCD image sensor						OUTPUT: 8 bits per channel RGB images printed at 300 dpi		
Megapixels	Sensor resolution Pixels		Sensor size mm		File size MB	Output print size inches	
	w	h	w	h		w	h
16.6	4992	3328	36	24	47.5	16.6	11.1
12.7	4368	2912	35.8	23.9	36.4	14.6	9.7
10.1	3888	2592	22.2	14.8	28.8	13.0	8.6
8.2	3504	2336	22.5	15	23.4	11.7	7.8
7.1	3072	2304	5.7	4.3	20.3	10.2	7.7

Figure 2.13 Sensor resolution, dimensions, file size and printed output.

Features of digital cameras

Digital image capture is a complex process. The signal from the sensor undergoes a number of processes before it is finally written to an image file. The processes are carried out either on the sensor itself, in the camera's built-in firmware or via camera software, in response to user settings. They are designed to optimize the final image according to the imaging conditions, camera and sensor characteristics and output required by the user. The actual processes and the way they are implemented will vary widely from camera to camera. Some are common to most digital cameras however. They will be covered in more detail in other chapters, but are summarized below. They include:

- *Signal amplification*: This may be applied to the signal before or after analogue-to-digital conversion; this is a result of auto exposure setting within the camera and ensures that the sensor uses its full dynamic range. In effect the contrast of the sensor is corrected for the particular lighting conditions.
- *Analogue-to-digital conversion*: The process of sampling and converting analogue voltages into digital values.
- *Noise suppression*: There are multiple sources of noise in digital cameras. The level of noise depends upon the sensor type and the imaging conditions. Adaptive image processing techniques are used to remove different types of noise. Noise is enhanced if the camera gets hot (the sensor is sometimes cooled to reduce the noise levels), also if long exposures or high ISO settings are used.
- *Unsharp mask filtering*: Used to sharpen edges and counteract blurring caused by interpolation.
- *Colour interpolation (demosaicing)*: This is the process of calculating missing colour values from adjacent colour-filtered pixels.

These are sensor specific, in-built and not user controlled. Additionally, settings by the user will implement processes controlling:

- *White balance*: The image colours (the gamut) are shifted to correct for the white of the illuminant and ensure that neutrals remain neutral. White point setting may be via a list of preset colour temperatures, calculated by capturing a frame containing a white object, or measured by the camera from the scene. In film cameras, this requires a combination of selecting film for a particular colour temperature and using colour-balancing or colour-correction filters.
- *ISO speed*: The sensitivity of the sensor is set by amplifying the signal to produce a required range of output values under particular exposure conditions. Again in film cameras, this would be achieved by changing to a film

of a different ISO. ISO settings usually range from 100 up to 800. Some cameras will allow ISO values up to 1600 or even 3200. The native ISO of the sensor however is usually 100–200. Anything above this is a result of amplification. Amplifying the signal also amplifies the noise levels and this may show up as coloured patterns in flat areas within the image.

- *Exposure and the image histogram*: This is a process of shifting the output values by amplification of the input signal, to ensure that the maximum range of output values is produced, ideally without clipping the values at the top or bottom of the range. The actual exposure measurements are taken through the lens as for a film camera and image processing takes care of the rest. To optimize this process the *image histogram* is provided in SLRs and larger formats to allow exposure compensation and user adjustment. This is a graphical representation, a bar chart of the distribution of output levels and is an accurate method of ensuring correct exposure and contrast, as viewing the image in the low resolution and poor viewing conditions of the LCD preview window may produce inaccurate results. In particular, it can be difficult to tell in the preview when highlight values are clipped, a situation to be avoided. The histogram will easily alert you to this and allow you to make necessary adjustments for a perfect exposure. For more information on exposure and the histogram, see Chapter 11.
- *Image resolution*: Many cameras, will allow a number of resolution settings, lower than the native resolution of the camera to save on file size. These lower resolutions will be achieved by down-sampling, either dropping pixel values completely if the image is being downsampled by a factor of 2, or by interpolating values from the existing sensor values.
- *Capture into a standard colour space*: With the necessary adoption of colour-managed workflow, a number of standard colour spaces have emerged. Capturing into a standard colour space means that the image gamut has the best chance of being reproduced accurately throughout the imaging chain (see Chapter 11 for further details). The two most commonly used standard colour spaces in digital cameras are sRGB and Adobe RGB (1998). sRGB is optimized for images to be viewed on screen. The slightly larger gamut of Adobe RGB encompassed the range of colours reproduced by most printers and is therefore seen as more suitable for images that are to be printed.
- *File quality (if image is to be compressed) and file format*: Most cameras will offer a range of different output file formats. The most common ones in digital cameras are JPEG, TIFF and RAW formats. The merits of these different formats are discussed in detail in Chapter 11. Of the three, JPEG is the only one that compresses the image, resulting in a loss of information. A quality setting defines the severity of the loss, file size and resulting artifacts. TIFF and RAW are uncompressed and therefore file sizes are significantly larger. TIFF is a standard format that may be used for archiving images without loss. RAW is more than a file format, as it results in almost unprocessed data being taken from the camera. With RAW images, the majority of the image processing detailed above is performed by the user in separate software after the image has been downloaded from the camera.

This short summary highlights some of the differences between using film and working digitally. The immediacy of results from digital cameras is somewhat counterbalanced by the number of settings required by the user before image capture. However it also highlights the high degree of control that you have. Many of the adjustments that would have to be performed optically with a film-based system, or by changing film stock, may be achieved by the flick of a switch or the press of a button.

Digital sensor sizes

One of the initial problems in producing digital cameras with comparable image quality to film was the difficulty and expense in manufacturing CCDs of equivalent areas. Many digital cameras have sensors which are significantly smaller than 35 mm format. The sizes are often expressed as factors, and they are based on the diagonal of a 1 in. optical image projected onto a sensor by a lens, which is close to 16 mm. Examples of the actual dimensions of some image sensors are shown in Figure 2.14, compared to typical film formats.

Sensor/format	Horizontal (mm)	Vertical (mm)	Diagonal (mm)	Aspect Ratio	Sensor Type	Camera types
Film						
35 mm	36.0	24.0	43.3	3:2	Film	Compact/SLR
120 mm	60.0	60.0	84.9	1:1	Film	Medium format/ various
Large format	120.0	101.6	162.6	5:4	Film	View cameras (5″ × 4″)
Digital sensors – consumer market						
1/5	2.6	1.9	3.2	4:3	CMOS	Mobile Phone
1/2.7	5.4	4.0	6.7	4:3	CCD/CMOS	Compact
1/2	6.4	4.8	8.0	4:3	CCD/CMOS	Compact
1/1.8	7.2	5.3	8.9	4:3	CCD/CMOS	Compact
2/3	8.8	6.6	11.0	4:3	CCD/CMOS	Compact
1	12.8	9.6	16.0	4:3	CCD/CMOS	Compact
1.8*	22.2	14.8	26.7	3:2	CMOS	SLR
1.8*	23.7	15.7	28.4	3:2	CCD	SLR
Digital sensors – professional market						
Full frame 35 mm	36.0	24.0	43.3	3:2	CMOS	SLR
Medium/large format back	36.9	36.9	52.2	1:1	Full frame CCD	Digital Back
Medium/large format back	48.0	36.0	60.0	4:3	Full frame CCD	Digital Back
Medium/large format back	49.0	36.9	61.0	4:3	Trilinear array CCD	Scanning back
Large format back	96.0	72.0	120.0	4:3	Trilinear array CCD	Scanning back
Large format back	100.0	84.0	130.6	4:3	Trilinear array CCD	Scanning back

* There are a variety of different sensors labelled 1.8 and sizes vary slightly between manufacturers

Figure 2.14 Dimensions of typical film formats and digital image sensors.

The small sensor sizes mean that in most digital cameras the focal lengths of lenses are significantly shorter than in film-based systems. This has a number of implications. First of all, it means that in the compact market, it has been possible to make much smaller camera bodies, and this is the reason that miniature cameras have proliferated (it has also made the tiny cameras used in mobile phones a possibility, see below). As for film camera formats, a shorter focal length means greater depth of field. The result of this is that using a shallow depth of field for selective focus on a subject is much more difficult in digital photography, because more often than not everything in frame appears sharp. This is one of the reasons that professionals often prefer a full-frame sensor of the same size as the equivalent film format, because in this case the lens focal lengths and depth of field will be the same as for film.

A further implication of the smaller sensors is that lens of focal lengths designed for film formats will produce a smaller angle of view when placed on a digital camera with a smaller sensor. This means that standard focal length lenses effectively become telephoto lenses (see Figure 2.15). The problem affects small-format SLRs, where lenses from the equivalent film format might be used, and also the larger formats when using digital backs with a smaller imaging area than the associated film back. It can also cause confusion when comparing the zoom lenses of two cameras with different-sized sensors. Effective focal length is sometimes quoted instead. This expresses the focal length as the same as a focal length of a lens on a film camera, usually 35 mm, based on an equivalent angle of view.

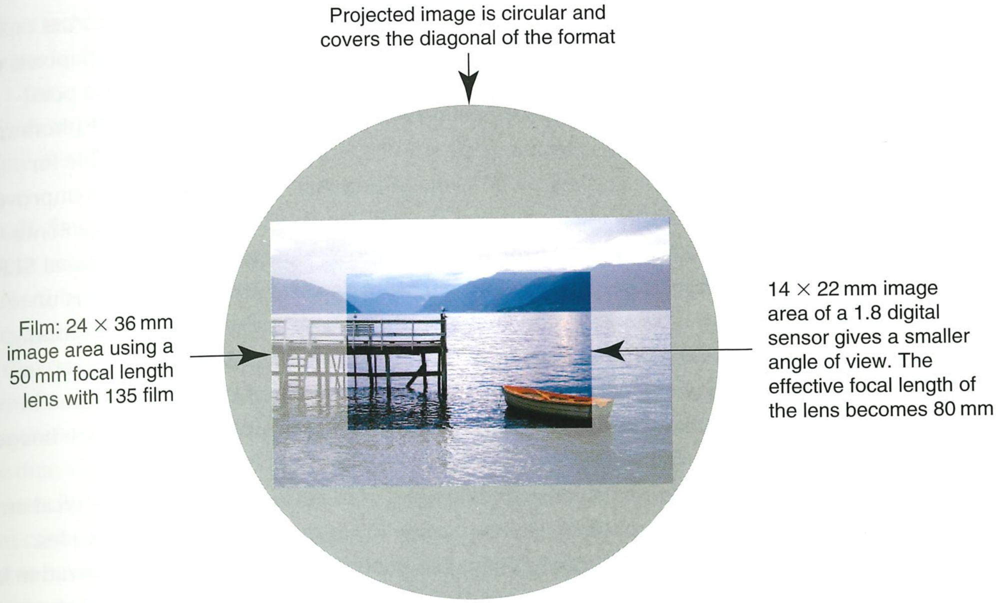


Figure 2.15 Change in angle of view as a result of smaller sensor size and focal length. Manufacturers often quote 'effective focal length' for digital lenses, which relates the field of view of the lens to that provided by the focal length of the lens in the related film format.

Digital camera equipment

Digital camera equipment is less easily classified by image format than film simply because of the huge variation in sensor size. Cameras can, however, be put into broad categories based upon the market for which they are aimed and like film cameras, this dictates the level of sophistication and cost of the equipment.

The equipment falls into a number of main types (see Figure 2.16):

1. Specially designed compact type cameras for point-and-shoot snapshots. Mobile phone cameras – with fewer features – can also be included in this category.
2. Hybrid cameras. There are a range of different designs, but they often bridge the gap between compacts and SLRs, containing many of the features of both.
3. Small-format SLR cameras. Up to 35 mm, these fall into two classes: Prosumer (or semi-professional) which are cheaper and aimed at the serious amateur, and professional SLRs based on existing film cameras, retaining their same 'front-end' features, but permanently housing a digital sensor in place of film.
4. Medium- and large-format digital backs. These are high resolution, capturing either an entire frame at once or in the larger formats scanning down the frame using a linear sensor. The majority are digital backs, which you simply attach and detach from your present medium- or large-format camera in the same way as a conventional rollfilm magazine or sheet film holder. There are a few available, however, that are built on to camera bodies.

Figure 2.16 Types of digital camera: (a) high-end compact, (b) hybrid and (c) professional SLR.

Point and shoot: Mobile phone cameras and compacts

At the lowest end of the market are mobile phone cameras. Pixel counts of up to 5 megapixels on sensors in mobile phones are now beginning to rival and surpass those in the compact point-and-shoot cameras of a few years ago. CMOS image sensors were first used in mobile phones; at the time the noise levels and low resolution associated with CMOS were unacceptable for other cameras, but the advances in the sensors in terms of both smaller pixel sizes and improved noise suppression have meant that image quality has steadily improved. These improvements have lead to the development of full-frame 35 mm CMOS sensors now used in professional SLRs. The optics on mobile phone cameras tend to be low quality, often plastic, however this is of much less importance bearing in mind the way in which these cameras are used. Interestingly, mobile phone cameras are currently the fastest growing part of the digital camera market. In recent years it has become common to see mobile phone images sent in by the public used in newspapers and television reports, where it would not have been possible to obtain such images unless a journalist had been on the scene.

There are a huge variety of compact cameras available, with many of the features typical on film compact cameras, such as built-in flash, a large variety of exposure and shooting modes, including movie modes and red-eye reduction. There has been a trend towards miniaturization by some manufacturers, aided by the ease of producing small CMOS sensors and the fact that many have scrapped viewfinders in favour of viewing the image on the LCD screen at the back. The other types of compact commonly available look more like an SLR, but tend to have smaller sensors. Nevertheless, recent models have sensors of up to 10 megapixels. Both types tend to be more automated, often without manual options. They may also only have digital zoom rather than optical zoom and output still image file formats may be limited to JPEG only. Prices are widely variable and continually coming down. The shelf-life of a particular camera model continues to decrease; often the next version in a successful range will be out six months after the last.

At the top end of the compact market are a couple of cameras aimed more at the professional (see Figure 2.16(a)) – the point-and-shoot for the professional photographer, if you will. They are significantly more expensive than the majority of compacts, up to three times more than those at the cheaper end but have fewer automated features, some without zoom lenses. They allow manual setting of most features; capture to RAW file format and sensor resolutions rival those of some SLRs. The cost is in the quality of sensor and the optics.

Semi-professional SLRs (Prosumer cameras)

These cameras are hybrids, with many of the automatic features of compact cameras, but with more of the manual controls available with SLRs. Where professional SLRs may be sold as camera body only, these tend to be marketed as all-in packages. Currently they do not include full-size sensors, i.e. of equivalent size to the film format. Actual sensor sizes are variable (see Figure 2.14). The upper limit of effective resolution of the sensors in these cameras is around 10.1 megapixels, which can theoretically produce an output print size of nearly 330 mm × 220 mm and a file size of around 30 MB. They may have a range of interchangeable lenses and a variety of accessories available and are sometimes compatible with the lenses from the equivalent film cameras. However, the smaller sensors mean that there will be a conversion factor between the lenses. The lenses are also of lower quality than the professional ranges. This is not to knock them however; some of the hybrid cameras produced by manufacturers such as Canon and

Nikon in recent years contain sensors that surpass the performance of those in professional ranges of a few years ago.

They are aimed at the serious amateur and their price reflects their hybrid status, being significantly more affordable, sometimes half the price (including lenses) of the professional equivalent (body only).

Full-frame SLRs

These cameras are the closest to conventional film formats and are aimed at the professional. The camera bodies are almost identical in design, apart from the image sensor and related optics, processing and the LCD screen on the back. Some manufacturers have even maintained the position of the main controls to make the transition from film to digital even easier. Sensors are full-frame; the same image size as 35 mm format and this means that there is no lens conversion factor required. The variation in price is therefore down to number of pixels and hence resolution, with an upper limit at the time of writing of around 16 megapixels, giving an output file size of nearly 50 Mb. Often sold as a camera body only (although some may come with cheaper lenses), they are designed to replace the film camera body in a professional kit, without requiring additional lenses or accessories. They tend not to have the array of automatic features of their semi-professional counterparts, with fewer modes and more manual control. These cameras have been widely adopted by photojournalists, in particular sports photographers, who often carry laptops as part of their kit and are able to download, crop and adjust their images before sending them wirelessly to their picture editors within a matter of minutes. In these types of photography, speed is of the essence and can mean the difference between your images, or someone else's, being used and syndicated.

There are also a number of medium-format full-frame digital SLRs available. Significantly more expensive, the sensors are larger than those used in 35 mm, but smaller than the physical dimensions of their film equivalent (36 mm × 48 mm is quite typical). More commonly available are digital backs for this format (see below).

Digital backs

For highest quality digital images intended for big prints, larger file sizes are required. This is made possible by fitting a digital back to a rollfilm SLR or view camera (see Figure 2.17). At this level, CCDs dominate. There are two main types: either frame arrays, which capture the entire frame at once, and are mainly medium format (although some can be attached to large-format camera bodies), or digital scanning backs, which use a trilinear CCD array (three rows of sensors, each capturing red, green or blue), and are designed for both medium and large-format cameras. The single shot arrays are not equivalent in size to their film counterparts, the largest currently available at around 49 × 37 mm, but with pixel counts of up to 7216 × 5412 (39 million), a sensor of this size produces image files of over 100 MB and resolution easily matches that of medium-format film.

(a) (b)

Figure 2.17 Digital backs: (a) A digital back for a medium-format camera (image courtesy of Phase One, Inc.), (b) a scanning back containing a trilinear CCD array for a large-format view camera (image courtesy of Better Light, Inc.).

Because digital scanning backs physically track across the camera image plane throughout an exposure, subject matter is limited to still-life as both camera and subject must remain still for a couple of minutes. Therefore they cannot be used with flash, and using tungsten illumination you must avoid any lighting intensity variations (such as minor flickering) because this will show up as a band across the picture. A full colour image of many millions of pixels is built up line by line to give image files at the top end of the scale of over 400 MB.

Clearly, dealing with files of this size is a completely different matter compared to the convenience of using digital SLR. There are huge storage requirements involved and processing must be done predominantly on a peripheral computer, therefore digital large format is much more likely to be used in a studio setting than its analogue counterpart.

Comparing digital and silver halide camera equipment

Advantages of digital:

- You get an immediate visual check on results (for example, displayed on a large studio monitor screen).
- No film or lab costs, or liquid processing in darkrooms.
- Sensitivity can be altered via ISO speed setting to match a range of lighting conditions.
- Exposure can be checked using the histogram to ensure correct scene intensity/contrast and to prevent highlights being 'blown out'.
- You can erase images, and reuse file storage, on the spot.
- Colour sensitivity is adjustable to suit the colour temperature of your lighting.
- Camera images can be transmitted elsewhere rapidly and wirelessly.
- Digital image files can feed direct into a designer's layout computer – ideal for high-volume work for catalogues, etc.
- Extensive ability to alter/improve images post-shooting.
- Digital image files are theoretically permanent, if correctly archived.
- Silent operation.

Disadvantages of digital:

- Much higher cost of equipment; this includes powerful computing back-up with extensive file capacity (RAM) necessary for high-resolution work. The technology is continuing to develop, meaning that equipment may require frequent updating, another source of expense.
- There are a huge range of knowledge and skills required to keep up with changes in the imaging systems, to ensure that your methods match standard workflows within the industry and to maximize the potential of the equipment. This needs extra investment from you in terms of both time and money.
- Digital workflow is not simply restricted to capture, but requires an imaging chain consisting of other devices such as a monitor and printer.
- Correct colour reproduction of a digital image from input to output requires the understanding and implementation of colour management which is a complex and still developing process.
- Silver halide film still offers excellent image resolution at low cost – roughly equivalent to 3 billion pixels for every square centimetre of emulsion. Also colour prints, particularly in runs, work out much cheaper by traditional neg/pos chemical methods.
- The limits to final acceptable image size are highly influenced by the number of pixels per inch the camera sensor codes within a file. So when planning a large final print you must start with a camera delivering sufficient pixels.
- High-resolution systems based on scanning are limited to still-life subjects.
- Cameras with digital sensors, like computers, are adversely affected by heat (i.e. from tungsten lamps).

SUMMARY

- The 35 mm film format is the smallest used by professionals. These systems are the most portable, versatile and the cheapest, with the largest range of accessories. Using 35 mm camera equipment you gain the benefit of latest technology at competitive prices. However, equipment may be either too automated or offer excessive options which get in the way. Consider manual override to be essential.
- Medium-format cameras offer a sensible compromise between equipment mobility and final image quality. As well as SLR and direct viewfinder types, shift cameras and monorail designs are made for rollfilm format. Often they allow use of interchangeable film magazines, instant picture and digital backs. However, equipment is expensive, and has a smaller range of lenses than 35 mm. Using this format also means less depth of field and narrower choice of film stock.
- Large-format view cameras demand a slower, more craft-knowledgeable approach. They tend to be expensive, yet basic. The range of lenses is limited, with relatively small maximum apertures, but most often give excellent coverage to allow you to utilize comprehensive movements for architectural, still-life and technical subject matter. You can shoot and process pictures individually, and their size means that large prints show unique detail and tonal qualities.
- It is vital to have reliable camera technique – get into the habit of routine precautionary checks before and during shooting. Look through the back of the empty camera to see that the shutter, aperture and flash work and that there are no obstructions. Take an instant-picture shot before and after a session. Carry a spare body or some back-up camera; an exposure meter; spare batteries – plus a screwdriver.
- Digital imaging is now the dominant means of image production for the consumer photography market, but remains a developing area. The high cost and limitations of larger digital formats mean that certain sectors of the professional photography market still work with film.
- Professional digital camera systems aim to match image format and resolution for the three main formats used in film systems.
- Currently, digital cameras use one of two types of image sensors, the charge-coupled device (CCD) or the complementary metal-oxide semiconductor (CMOS), both of which use a silicon-based 'array' of picture sensing elements (pixels) to convert light falling on the sensor into electronic charge.
- Once the image has been recorded on the image sensor, it is processed, transferred off the chip, and stored as an image file, consisting of binary digits ('Bits') representing the image data. If archived properly, a digital image file may be stored permanently and reproduced as many times as required without any loss of quality.
- Digital images are *sampled*: spatially, they consist of discrete non-overlapping elements usually arranged in a rectangular grid. They are also sampled in terms of their colour values (*quantized*), as pixels may only take a fixed range of values, determined by the *bit depth* of the image file. These two factors determine the image file size, ability to represent fine detail and ultimately the quality of the final image.
- Resolution has a number of different meanings in digital imaging and it is useful to understand these different definitions. Fundamentally it describes the detail-recording ability of an imaging system. Resolution of a digital image is normally expressed in terms of number of pixels. Resolution in a digital camera also refers to number of pixels, but may refer to interpolated resolution rather than the real resolution of the chip and can therefore be misleading as a figure of merit. For other devices, resolution is usually quoted in terms of numbers of pixels (or dots) per inch – this defines the level of detail captured at input and the dimensions of the image at output.

- Although the front-end design of digital cameras, particularly for professional formats, is the same as that of film cameras, digital cameras have a number of features and settings not required with film. These are changed via a software user interface, either on an LCD screen on the back of the camera or remotely using a peripheral computer. This offers you a huge range of options at your fingertips, but it adds an extra layer of complexity to the capture process, however this is counterbalanced by the ability to view immediate results and adjust as necessary.
- Digital camera settings to change the white balance of the sensor and ISO speed rating to match illumination means that a wider range of imaging conditions are catered for by the same sensor. Correct exposure in digital cameras is further aided by the image histogram, allowing fine tuning of brightness and contrast. In film systems sensitivity and colour balance is achieved using different film stocks and filters and is therefore a more complicated and time-consuming process.
- The physical dimensions of digital image sensors vary widely and are often smaller than film formats. This has implications for the optics of the cameras, as the smaller format means that shorter focal length lenses will produce the same field of view as those used on film cameras. Shorter lenses mean smaller cameras and larger depth of field. More recently professional cameras containing full-frame sensors that are the same size as their equivalent film format have been developed. For these cameras, there is no change in terms of field of view or depth of field when lenses for equivalent film formats are used with them.
- Digital camera systems may be loosely classified according to the market that they are aimed at. The largest section of the market comprises compact cameras and mobile phone cameras. These vary hugely in design and features. More expensive than these are semi-professional (Prosumer) cameras, which are aimed at the serious amateur, are usually SLR in design and tend to have many of the features of professional 35 mm cameras.
- For the professional market, a number of manufactures now make 35 mm full-frame SLRs, which are designed to match their film-based equivalents in terms of quality and features. These are currently significantly more expensive than either the film versions or the semi-professional SLRs.
- There are a range of medium-format digital camera systems available. A few manufacturers make SLR cameras, but many professionals opt for digital backs designed to be used with existing equipment. Currently, the sensor dimensions are smaller than the 120 mm film; however image quality is generally regarded as equivalent.
- Large-format digital systems are usually digital backs containing either an area CCD array of smaller dimensions than large format films, or a tri-linear array of CCD elements scanned across the image. Full-frame sensors are more difficult to successfully manufacture to this size. The scanning backs, which do match the imaging area of the equivalent films, require still-life subjects and non varying light sources to prevent image artefacts such as banding.
- The decision to move to a digital workflow requires careful consideration. The technology continues to evolve and equipment will need to be updated on a more regular basis than film-based systems.
- Digital camera systems are more expensive and require understanding of a range of different issues on top of those required for film photography. However, the versatility of the systems and the ability to view and alter images immediately post capture offer profound advantages compared to the time required to produce an image using film.
- Top-end digital cameras can deliver results fully the equal of equipment using silver halide materials; capital cost is far higher, although reducing every year.

1 This project involves the use of the histogram as an exposure tool:

(a) Set up a still-life scene using a variety of objects, including a test chart, if you have one, such as the Macbeth colour checker chart. If not, ensure that there are a range of colours in the scene and that there is one white, one black and one mid-grey object included. Set the lighting so that there is a range of approximately seven stops between shadows and highlights (you can check this by zooming in and taking exposure readings from these areas).
(b) Ensure that a memory card is in the camera, turn the camera on and perform a complete format. Set the speed to 200 ISO. Set the colour space, if possible, to Adobe RGB.
(c) Take 5 bracketed exposures, in increments of 1 stop, from 2 stops below correct exposure to 2 stops above.
(d) Ensure that the histogram is displayed when the images are played back. Examine how the shape of the histogram changes as the exposure changes. Identify the point at which shadows or highlights within the image are clipped – this will show on the histogram as a peak at either side. Your camera LCD screen may also display clipped areas within the image.

2 This project involves investigating the ease of use and results obtained using the different methods of setting white balance in your camera:

(a) Select a number of scenes under different lighting conditions, e.g. daylight, tungsten, and fluorescent. In each, include a white object, such as a sheet of paper, and a mid-grey object, such as a Kodak grey card.
(b) Set the speed to 200 ISO throughout. Find correct exposure, set colour space to Adobe RGB and file format to JPEG (high quality).
(c) Take shots of each scene using the different white balance methods available: (i) Auto-white balance, (ii) Pre-set to the light source or colour temperature and (iii) Using custom white balance (you will need to check the instructions for the camera to do this – it usually requires a reference frame of a white object).
(d) Download the images to your computer and view them side by side on screen in an imaging application such as Adobe Photoshop. Identify the method that works best for each light source.

3 This project involves the capture of a scene using the different ISO speed settings to investigate the effect on image quality and noise levels:

(a) Use the camera on a tripod for one scene in daylight conditions and another scene with low light conditions (not night conditions, but indoor using natural light, for example).
(b) For each scene shoot a range of images using all the possible ISO speed settings on your camera.
(c) Download and examine your images in Photoshop. Zoom into areas of shadow and mid-tone.
(d) Identify at which ISO speed noise begins to be visible and in which areas it is most problematic. You may find you get different results depending on the lighting conditions.
(e) You might want to further extend this project by trying out some noise removal techniques (see the Image Manipulations chapter).

PROJECTS

PHOTOGRAPHY/ DIGITAL PHOTOGRAPHY

Focal Press Books: for photographers, by photographers

Review of previous edition:
'This is an important book. It should be in the library of every photographic establishment, educational or commercial, and on the personal shelves of every budding professional photographer.'
The British Journal of Photography

- The essential guide to advanced photography, with a long-established reputation as the technical 'bible' for aspiring professionals
- Packed with practical advice, insights and techniques to help you achieve expert results
- Fully updated to cover new digital technologies, workflow and methods from image manipulation to colour management and archiving

The 7th edition of ***Langford's Advanced Photography*** brings this bestselling advanced guide right up to date, with Michael Langford's renowned level of technical detail now extended to cover all the latest in digital technology.

Whether you are a serious enthusiast, a student or a training professional, this book covers it all; from cameras, lenses, digital imaging sensors and films to insights into photography as an industry and how to manage accounts, charge for jobs and self-promote to kick start your career. Genres are explored, from portraiture and photo-journalism to aerial photography, and in-depth coverage of digital manipulation, film processing, colour theory, archiving and storage provides everything you need to know to extend your art into professional realms.

Michael Langford, a renowned author, teacher, and practitioner, inspired thousands and taught many more as Photography Course Director at the Royal College of Art, London, UK.

Efthimia Bilissi is Senior Lecturer and Admissions Tutor for Photography and Digital Imaging at the University of Westminster, UK. She has edited a number of magazines on photography and is a previous winner of The Royal Photographic Society's Selwyn Award.

The Langford Series

Langford's Starting Photography The ultimate introduction to photography, covering all the beginner photographer needs to start achieving great results.

Langford's Basic Photography The authoritative classic for beginning to intermediate photographers wanting to understand the principles and practice of photography.

Langford's Advanced Photography The comprehensive and respected guide for serious photographers wanting to advance their skills and produce professional results.

Cover photograph by by Bernardo Medina ('foureyes') 4eyes@4eyesphoto.com

LEVEL:
INTERMEDIATE/ADVANCED

$47.95 / £26.99

ISBN 978-0-240-52038-4

9 780240 520384

ELSEVIER

Focal Press

Focal Press
An imprint of Elsevier
www.focalpress.com