Narrow depth of field can be exploited to throw your main subject into sharp focus and tone down a confusing background.

Depth of field

Depth of field is one of the photographer's most important creative tools. But digital cameras can throw a spanner in the works, and it's all because of their smaller sensor sizes. Rod Lawton explains

Strictly speaking, photographs are only truly sharp at one specific focus point. Anything further away or nearer grows progressively out of focus. When it's sharply focused, a lens reproduces an area of detail as a point on the sensitised surface of the film or CCD.

When the focus is slightly shifted, the point of light spreads out to form a disc, and the greater the focus shift, the bigger the disc. When talking about depth of field, this disc is called the 'circle of confusion'.

Although there is technically only one sharp plane of focus when you take a shot, there's a limit to the extra detail the human eye can discern in a printed image. This means that in practice, there's a zone of 'apparent' sharpness rather than a single plane. This is called the 'depth of field'.

The depth of field that's available depends on a number of factors, and depth of field can be controlled using lens aperture and different focal lengths.

Circles of confusion

The first factor that affects depth of field is the degree to which you want to enlarge your images. The bigger the enlargement, the more inherent sharpness you need. Specifically, the maximum size of the 'circle of confusion' that's acceptable is reduced. To compare depth of field from one camera, lens and aperture with another, we need some kind of simplified standard. Most experts settle on 'typical' viewing conditions: a 10

Calculating hyperfocal distance

'Prosumer' digital camera Image area 7mm across, 'circle of confusion' 0.006mm

Aperture Settings	Focal length: 7mm (35mm equivalent)	Focal length: 14mm (70mm equivalent)	Focal length: 21mm (105mm equivalent)
f2	4.1m	16.0m	36.8m
f2.8	2.9m	11.6m	30.0m
f4	2.0m	8.2m	18.4m
f5.6	1.4m	5.8m	13.0m
f8	1.0m	4.1m	9.2m
f11	0.7m	2.9m	6.5m

Digital SLR Image area 24mm across, 'circle of confusion' 0.02mm

Aperture Settings	Focal length: 7mm (35mm equivalent)	Focal length: 14mm (70mm equivalent)	Focal length: 21mm (105mm equivalent)
f2	14.4m	55.2m	122.5m
f2.8	10.2m	39.1m	86.6m
f4	7.2m	27.6m	61.3m
f5.6	5.1m	19.5m	43.3m
f8	3.6m	13.8m	30.6m
f11	2.6m	9.8m	21.7m

35mm film SLR Image area 36mm across, 'circle of confusion' 0.03mm

Aperture Settings	Focal length: 7mm (35mm equivalent)	Focal length: 14mm (70mm equivalent)	Focal length: 21mm (105mm equivalent)
f2	20.4m	81.7m	183.8m
f2.8	14.4m	57.6m	129.9m
f4	10.2m	40.8m	91.9m
f5.6	7.2m	28.9m	65.0m
f8	5.1m	20.4m	45.9
f11	3.6m	14.4m	32.5m

x 8-inch enlargement displaying as much detail as they human eye can perceive. Working backwards, this gives a circle of confusion size, on 35mm film, of around 0.03mm. We can use this figure as the basis for calculations for digital cameras and their smaller sensor sizes (which will require smaller circles of confusion because of the greater degrees of enlargement).

A digital SLR with a sensor measuring around 24 x 18mm will need a circle of confusion of 0.02mm, while typical prosumer digital cameras have sensitised areas around 7mm across (yes, they really are that small), meaning a maximum circle of confusion of just 0.006mm.

There are calculations you can use to work out the depth of field available for any lens, aperture and focusing distance. You can also work out the 'hyperfocal distance' – the focus setting that offers depth of field which extends to infinity and as near as possible to the camera for any given lens and aperture. See our hyperfocal distance table to discover the hyperfocal distances for a range of camera types, lens focal lengths and aperture settings – it makes very interesting reading.

Practical results

This is all getting a bit technical, isn't it? You don't have to understand the optical theory in detail to exploit depth of field effects, of course. All photographers know that smaller apertures (and shorter focal length lenses) give more

Hyperfocal distance tables

Trying to produce depth of field tables for different apertures, lenses, cameras and focusing distances would fill a book. We've settled for a simpler table listing 'hyperfocal' distances (above). This is the distance at which you need to focus with any camera/lens/ aperture combination for infinity to be sharp and as much of the scene as possible nearer the camera to be acceptably sharp too. This is most useful for landscape photographers and anyone else who needs to get both near and distant detail sharp.

How to use these tables

1 Pick the type of camera you're using; 'prosumer' digital camera, digital SLR or 35mm film SLR.

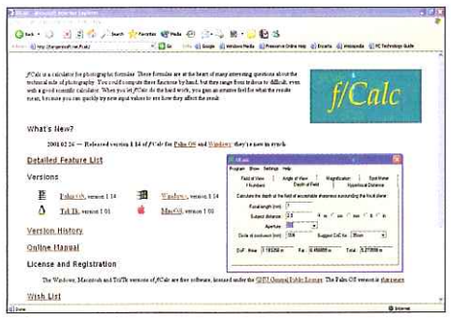
2 Locate the column corresponding the to focal length you're using.

3 Look down the column to find the distance at which you need to focus for maximum depth of field.

4 Halve the focus distance to find the near limit of the depth of field (the far limit is always infinity).

Depth of field calculations

There are mathematical formulae for calculating the near and far focus points for any lens, aperture, focal length, subject distance and circle of confusion size. Be warned, though, that your maths and algebra have to be pretty sharp to make them work. Instead, why not let someone else do it for you? You'll find a handy depth of field calculator at **www.shuttercity.com/DOF.cfm**, although this one only applies to 35mm film cameras. For more extensive calculation options (and a downloadable DOF calculator), visit **tangentsoft.net/fcalc** (there's no 'www' in this address). You'll find Windows, Mac and even Palm OS versions here.



You'll find a number of online DOF calculators on the Web, including this downloadable calculator called f/Calc.

Why aperture priority?

Most high-end digital cameras offer shutter priority and aperture priority automation in addition to a fully programmed mode. Aperture priority has always been the favourite of the two because it's the most immediately useful. Aperture-priority automation and a grasp of depth of field principles enable you to quickly choose an aperture that provides the depth of field you need – the shutter speed looks after itself. For quick shooting with compact digital cameras (which suffer badly from autofocus lag), choose an aperture (f4 can be plenty small enough), set the focus manually to around 2m, then shoot away in aperture-priority mode for sharp, lag-free shots.

Aperture-priority is useful for sports, too. If you set the widest aperture, you know that the camera is shooting at the fastest shutter speed possible, helping to freeze the action.

Fed up of autofocus lag on compact digicams? Manually focus at 2m, set the aperture to f4 and shoot in aperture-priority mode for fast, focus-free, sharp shots from 1m to infinity.

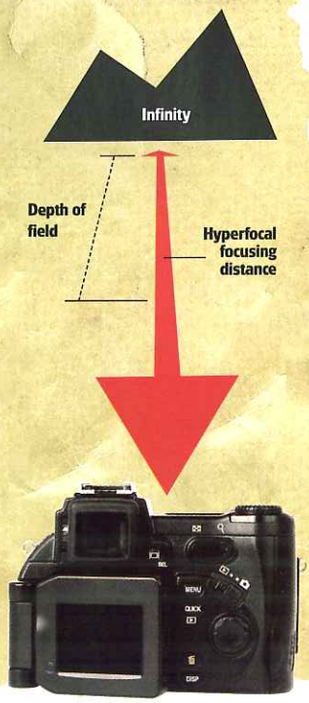
With just 60 seconds' work in Photoshop, we've produced a tolerably convincing depth of field effect which concentrates interest on the foreground.

Hyperfocal fun

Maximise your camera's depth of field by finding out the optimal focusing distance

The 'hyperfocal' distance is particularly useful for landscape photographers, but it can also be a valuable focus-free setting for anyone who needs to shoot in a hurry.

For any lens/aperture/ camera combination, there's a focusing distance that offers maximum depth of field, from infinity to a point roughly halfway between the focused distance and the camera. See our separate hyperfocal distance tables on page 61 to work out what the distance is for your equipment and settings.



Calculating the hyperfocal distance for your camera will enable you to get as much of an image in focus as possible.

Simulating depth of field

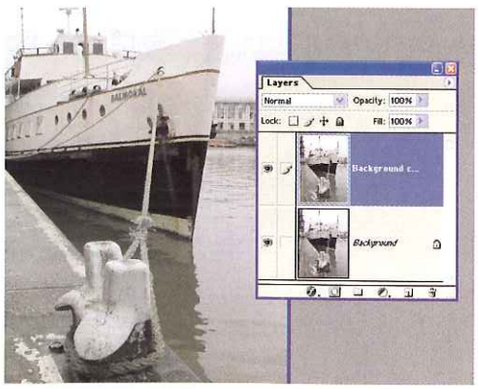
Compact digital cameras are rubbish at depth of field effects. They provide so much of the stuff at normal focal lengths that you need to cheat if you want to duplicate all those differential focus effects you've used in the past. We're going to show you a quick and dirty way to do it....

BEFORE: Everything in this shot is sharp, even the buildings in the distance.

depth of field, while shallow depth of field (for portraits, maybe) is produced using wide apertures and longer focal lengths.

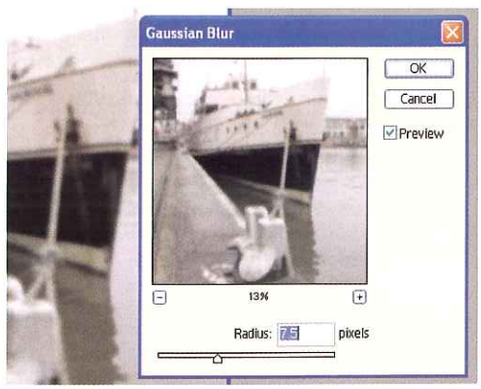
Most of us have pretty good practical experience of handling depth of field with 35mm as well as medium- and even large-format cameras, but digital cameras are a different proposition. They use much smaller image sensors (particularly the compact 'prosumer' models), and this has a big impact on depth of field. In a nutshell, with compact digicams you'll typically have so much depth of field you won't know what to do with it. More annoyingly, if you want shallow depth of field, it's extremely awkward to generate.

Our hyperfocal distance tables give some idea of the depth of field offered by prosumer models. They suggest that if we take a PowerShot G and set an aperture of f4 and a manual focusing distance of 2m, everything between 1m and infinity should come out sharp – and it does. This makes a bit of a mockery of



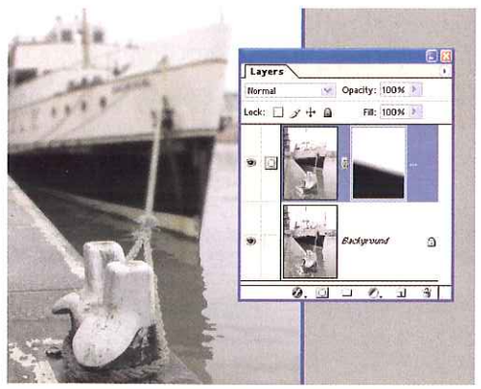
1 Duplicate to activate

There are a number of ways of selectively blurring your images, but this is one of the quickest, and it's also easily editable or reversible later on. The first job is to duplicate the current image layer in the Layers palette.



2 The world is blurred

Next, we'll use the Gaussian Blur filter to blur the duplicated layer and produce the maximum out-of-focus effect required for the far distance. The next step is to carefully blend the two layers together.



3 Layer effects

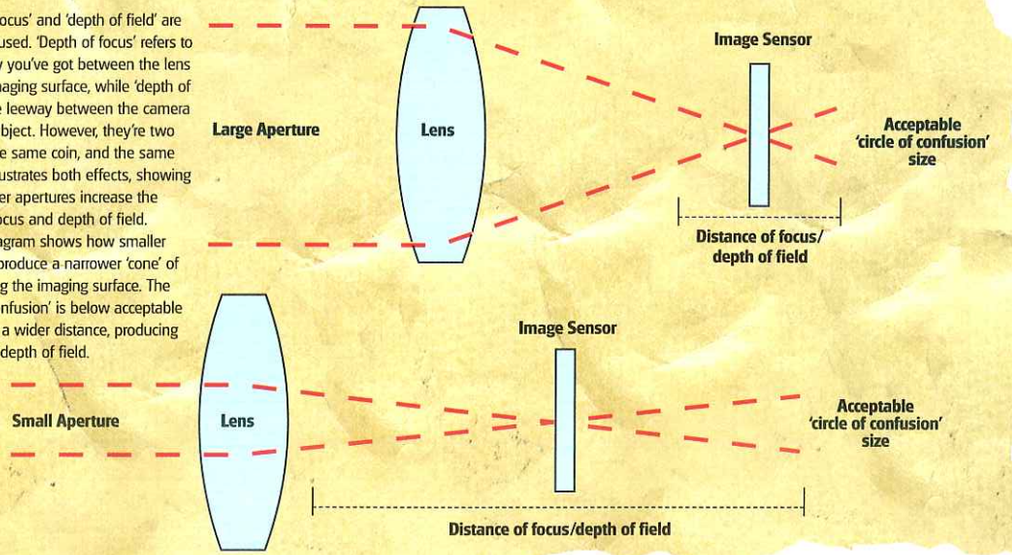
Finally, we'll create a layer mask for the duplicate layer and use the gradient tool, choosing an angle that best matches the objects and perspectives in the shot. You can also use circular gradients or paint on the mask manually with a brush.

Depth of field and focus

Discover how smaller aperture settings can be used to manipulate focus and depth of field

'Depth of focus' and 'depth of field' are often confused. 'Depth of focus' refers to the leeway you've got between the lens and the imaging surface, while 'depth of field' is the leeway between the camera and the subject. However, they're two sides of the same coin, and the same diagram illustrates both effects, showing how smaller apertures increase the depth of focus and depth of field.

This diagram shows how smaller apertures produce a narrower 'cone' of light striking the imaging surface. The 'circle of confusion' is below acceptable limits over a wider distance, producing far greater depth of field.



sophisticated autofocus systems. If you routinely use a compact digital camera at its widest focal length, you don't need any of them.

If you thought it was a bit of a cheek that some low-cost, fixed-focal-length digicams had fixed focusing too, now you know why – there's scarcely any need to focus cameras like these. Focusing only comes into play with close-ups and telephoto shots, and then only at the wider apertures. If you plan to use compact digital cameras extensively, it's best to forget about all those creative depth of field effects you've used in the past. Either that, or buy a digital SLR instead. If you can afford a full-frame model, all the better.

The digital dimension

Still wondering why digital cameras offer so much depth of field? After all, the greater degree of enlargement needed for same-sized prints means a smaller allowable circle of confusion and hence narrower depth of field. In practice, though, this is more than outweighed by the smaller size of the optical system.

This can be complex to put across technically, so if it helps, look at it this way. Sheet-film monorail and view cameras have very narrow depth of field, while medium format offers more and 35mm more still. It's a logical progression to expect the smaller sensors of digital cameras to yield most of all. The smaller the optical system you're dealing with, the further away everything 'looks' to the camera. (Depth of field increases, as we know, with distance.)

To a view camera, anything in the same room is practically a close-up. To a digicam, the far end of your studio is more like a distant landscape. This is nothing to do with the angle of view, more the relative size of your camera's optical system and the subject you're shooting.

Remember that as depth of field increases, the rate at which the image softens outside that range diminishes. Not only do prosumer digital cameras produce immense depth of field, they generate quite high levels of sharpness even well outside this range. DP

This image, shot on a Canon EOS 1Ds, shows that small apertures are capable of producing narrow depth of field.

Macro photography

Depth of field decreases as you get closer to a subject, so even smaller apertures can produce narrow depth of field. The shot above was taken with an EOS 1Ds, which has a full-frame CMOS sensor, so it has the same depth of field characteristics as a 35mm film camera. To take an arbitrary example, the depth of field available at a focal length of 35mm (equivalent), an aperture of f8 and a focusing distance of 0.5m with three different types of camera is as follows:

- **35mm film camera (or full-frame digital SLR)**
  Depth of field: 0.46-0.55m (0.09m, or 9cm)
- **Digital SLR (1.5x focal length factor)**
  Depth of field: 0.44-0.58m (0.14m, or 14cm)
- **Prosumer digital camera**
  Depth of field: 0.34-0.97m (0.63, or 63cm)

If your speciality is close-up or macro photography and you're plagued by insufficient depth of field, maybe you need to swap your high-end film equipment for a low-cost digital camera!

Fixed-focus cameras

Fixed-focus film cameras are cheap and nasty, so can the same be said of fixed-focus digital models like Kodak's CX4210 (below)? Actually, no. There's a strong argument that for fixed focal length (non-zoom) digital cameras like this one, focusing is an unnecessary distraction rather than a useful feature. No focusing, no focus lag!

Full-frame digital SLRs

Digital SLRs are very capable and prices are falling. However, with a couple of extremely expensive exceptions, they still use an image sensor smaller than a 35mm frame. This means you need to apply a 'focal length' factor of around 1.5 to your existing lenses. (A 28mm wide angle, for example, effectively becomes a 42mm lens when fitted to a digital SLR). This is a nuisance, especially for wide angle fans, because any optics wider than 28mm are increasingly expensive. Worse still, the smaller sensor area of digital SLRs means that they offer more depth of field. Admittedly, this can be an advantage for macro and landscape fans. But if you like to exploit depth-of-field and differential focus effects, it's another good reason to save up for a full-frame digital model like Canon's EOS-1Ds.

Depth of field control

If you let your camera do the focusing and leave it set to program AE exposure, you've got no control over depth of field. Try switching to aperture-priority mode at least. Canon's EOS SLRs have a handy 'depth-of-field AE' mode. Here, you select one focusing point in the scene, select a second, and the camera will automatically work out the correct focusing distance and aperture to get both sharp.