CAMERA BASICS

Introduction

Modern cameras are the result of literally decades of development. They have changed out of all recognition from the purely manual devices used in Victorian times by the founding fathers of photography. Once where the photographer controlled everything to ensure a focussed and correctly exposed image, the electronic marvels of today merely require the shutter to be pressed and the camera does the rest. Such is the refinement of these modern machines, the latest ones can even detect faces and whether the person is smiling, and usually very good results ensue.

It is tempting to allow the camera to manage itself, freeing the photographer to concentrate on composition. Indeed, the majority of pictures now taken usually involve some form of automation. As an example, it is no coincidence that the quantity and quality of sports pictures have improved dramatically over the years first with the introduction of automatic exposure, then automatic focus and finally image stabilisation.

Yet is anything lost by handing complete control to the camera? That most new cameras come with scene modes suggests that the use of different settings can make a difference. To get the most from photography and move on from point and shoot record photography, an understanding of how it works is essential.

The principles of photography have not changed since the time when Fox Talbot and others were conducting their experiments in the first half of the 19th century. Light enters through a lens and is focussed on a light sensitive medium, which records the image. Be it film or digital sensor makes no difference, although the two work in completely different ways to make an image of course. To ensure that sufficient light falls on the film or sensor when making an exposure, there are three separate controls – aperture, shutter and ISO.

Photography has a number of terms that initially seem daunting, but are actually easy to comprehend. Later in this article, there are explanations of how aperture, shutter speed and ISO can affect an image. An understanding of how these work will greatly assist in getting the best from your equipment and achieving improved results.

Camera Types

Before considering the various camera controls, an important consideration for many will be the type of camera to use. Up to the first few years of this century, cameras mainly used film, although towards the end of the 20th century, digital cameras started to become available. As with all new technologies, early examples were expensive and film remained the best choice for those seeking optimum image quality.

Today, the majority of cameras sold have digital sensors and record images to a memory card held in the camera. At the time of writing, the most common brands of film remain readily available for purchase and there are many people who continue to use it. By contrast, very few film cameras are available new and the most common source of supply is on the secondhand market. The principles

of photography remain the same whatever the type of camera in use, although the remainder of this section mainly applies to digital cameras.

The most common models are digital compact “point and shoot” style cameras. The cheaper models are largely automated and offer few controls to the user. More expensive ones retain the automation, but have more options. Used within their limitations, the image quality is often very good and many enthusiasts have one for when they do not want to or cannot carry a lot of camera gear.

The digital single lens reflex, or DSLR, is the most common type of camera used by those who want to take their photography beyond the taking of snapshots. The name comes from the mirror that sits in front of the film or sensor and allows the user to view the scene through the lens mounted on the camera. This is a significant advantage as it allows the use of a wide variety of lenses, which considerably enhances the versatility of this type of camera. efore the advent of digital cameras, where it is usual to compose using the LCD at the rear, this was the only way to view a scene exactly as it would be recorded.

Unlike a digital compact, DSLRs have interchangeable lenses which allow them to be adapted for the widest range of photographic uses. Lenses are attached with a bayonet mount, which is generally unique to each manufacturer. The lack of a facility to use components from different makes means careful consideration of an initial purchase; each additional item of equipment bought will increase the lock in to that particular system.

There is a new type of camera that is a hybrid between a digital compact and a DSLR, which replaces the latter type’s mirror with an electronic viewfinder. This results in a much more compact camera, whilst retaining the flexibility of changing lenses and it is entirely possible that this design will eventually supersede traditional DSLRs.

Lastly, there are medium format cameras. These are intended for professional use where image quality is paramount and are priced accordingly. Suffice to say, the price will deter all but the wealthiest amateur. Anyone using such a camera will already have more knowledge than is included in this article.

Sensor Sizes

When considering sensor size of digital cameras, the headline figure is the number of megapixels that it can record. There is an implicit assumption that the higher the number of megapixels, the better the end result will be as definition will be greater. In fact, manufacturers have literally made an industry of producing cameras with ever increasing megapixel counts to tempt consumers to upgrade to the next model. Is it really as straightforward as that?

The sensor is the most expensive component to manufacture for a camera. The manufacturing process is not perfect and if all the pixels on the sensor do not function correctly, it cannot be used. The greater the physical size of the sensor, the increased likelihood of dead pixels means that production yields reduce correspondingly, increasing costs.

Sensor size is important as there is a relationship between size and image quality. DSLR sensors are bigger than those in digital compacts, which also means that there is a corresponding difference

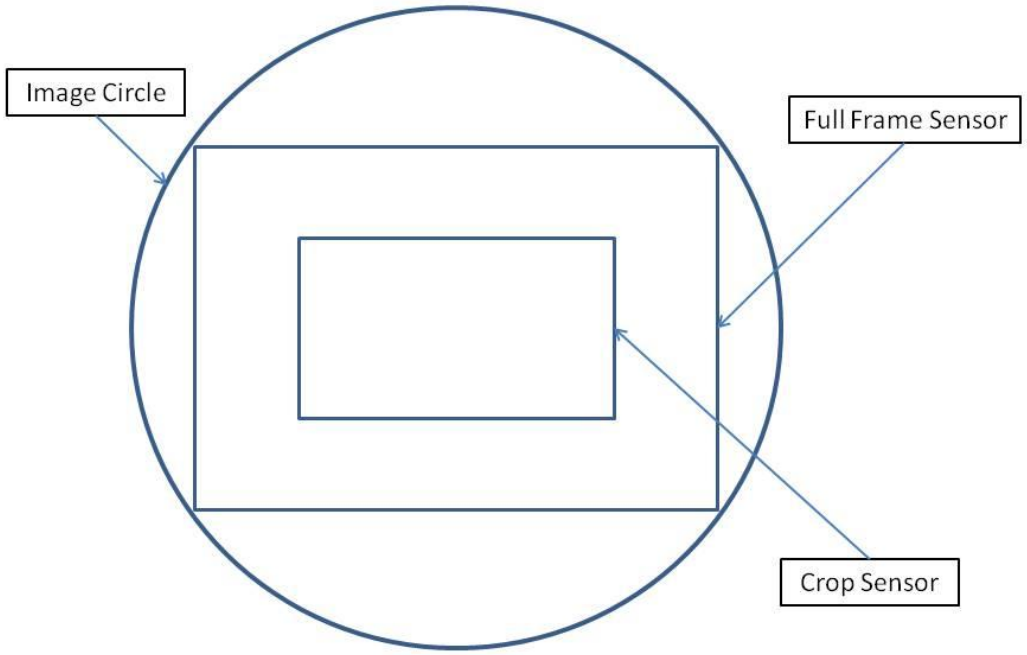
between the physical sizes of the cameras. The smaller the sensor, the smaller the rest of the camera can be and vice versa.

Consider two sensors, one in a digital compact and the other in a DSLR with both capable of recording 10 megapixels. The greater surface area of the DSLR sensor will mean that it can capture more light, which means that the electronic signal it records has to be boosted less. Since boosting a signal also amplifies any imperfections, the larger sensor will be capable of producing a better quality image.

There is further consideration of this topic in the section on ISO.

Crop Sensors

The majority of DSLRs have what are known as "crop sensors", a reference to the film SLRs on which they are based that use 35 mm film. Most DSLRs have sensors that are smaller than a 35 mm frame, partly for cost reasons and partly to reduce the size of the camera. With a lens designed for use on a 35 mm film camera, the sensor captures only the central part of the image.



The diagram above shows the circular image that a lens creates. The larger rectangle represents a full size sensor that is the same size as 35 mm film and which is just covered by the image circle. The smaller rectangle is a crop sensor and fits well within the image circle.

Shooting a scene with a lens first mounted on a 35 mm SLR and then on a DSLR with a crop sensor, the film camera will record more of the scene. Cropping the full size image yields the same result as the DSLR, hence the term crop sensor. It will also be seen that a crop sensor has a magnifying effect by reducing the effective angle of view and making objects appear closer.

The area inside the red rectangle shows the view that would be captured if a lens of the same focal length were mounted on a camera with a crop sensor, where only the central part of the image would register.

Since many people are familiar with how lenses function on 35 mm cameras, crop sensors are given a crop factor, which is typically around 1.5. This size is also referred to as APS-C, a reference to a film format smaller than 35 mm that a consortium of manufacturers introduced in 1995. The crop factor is a multiplier that enables users to gauge how a lens will behave on a crop sensor camera. Hence a 50 mm lens on a SLR will be equivalent to 75 mm on a DSLR with a 1.5 crop sensor.

The higher the crop factor, the smaller the sensor will be. 1.5 or 1.6 are the most common, although there are a very few cameras that have 1.3 crops sensors. The Four Thirds system has a crop factor of 2 and is unique in that it was designed from the outset for digital cameras only - Four Thirds film cameras simply do not exist. A digital only format has certain advantages since the camera and lens design does not have to take account of a 35 mm legacy, but the smaller sensor does require some compromises. The section on ISO has more about this.

A number of manufacturers include in their ranges at least model which has a full frame sensor that is the same size as 35 mm film. Some modern lenses are designed specifically for crop sensors, which precludes use on a film SLR or full frame DSLR. In the future, as digital technology develops, it is likely that this anomaly will disappear over time with the introduction of new camera systems that are not based on those designed for film.

The next section on Aperture and Lenses also looks at the effect of crop sensors on lenses.

Aperture and Lenses

A lens is essentially a tube with optical elements inside through which light from a scene is focused onto the recording medium. The maximum amount of light that can pass through a lens is denoted by its aperture or f number. Whilst the maximum aperture of a given lens cannot increase, it can be reduced by a diaphragm that makes the aperture smaller. A lens with a low f number is described as a fast lens, whilst higher numbers denote a slower one.

The f number sequence is 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, 64, with each increase or decrease in f number denoting a halving or doubling in the amount of light transmitted through the lens. It is also possible to have intermediate apertures, so f/3.5 is midway between f/2.8 and f/4 for example. This might seem confusing, but in reality it does not matter. Our eyes adjust automatically to prevailing light levels and do not perceive differences in the same way such as with length or volume of a liquid, for example. The camera controls or the aperture ring on a lens set the aperture and the photographer need only be aware of whether a wide or small aperture is in use, remembering the lower the f number, the wider the aperture.

Lenses are also described by their focal lengths, which are expressed in millimetres. A low number such as 20 indicates that a lens has a wide angle of view, while higher numbers such as 200 show that the lens has a narrower angle of view and magnifies objects by making them appear closer. These are often referred to as telephoto or long lenses.

In order to create image magnification, the optical elements inside a telephoto lens are placed further apart than for a wide-angle one. Since this lengthens the path through which the light travels, telephoto lenses tend to have smaller maximum apertures and are physically longer compared to shorter focal lengths.

There are fast telephoto lenses available, which are made possible by increasing the diameter of the elements, but this has a detrimental effect on both weight and cost. The larger an element, the more difficult it is to eliminate defects in the manufacturing process and being made of glass, the lenses are heavier. Increasing the maximum aperture of a telephoto lens can easily treble the cost, typically becoming specialist equipment mainly used by professionals.

The introduction of crop sensor DSLRs has meant that for any given focal length, there will be a telephoto effect compared to conventional 35 mm equivalents. This has been a boon for those who shoot subjects such as nature or sport, but the downside is wide-angle lenses have become more moderate. Manufacturers have addressed this by introducing lenses with short focal lengths specifically designed for crop sensors. By their very nature, they are incompatible with film cameras or full frame DSLRs as the image created by the lens will not fill the entire frame.

A lens with a fixed focal length is known as a “prime”, while the majority of lenses available today are zooms that have variable focal lengths. Since a fast lens requires a wider tube and hence larger internal elements, they are very expensive to produce and weight increases dramatically. Primes have a simpler optical structure and at the shorter focal lengths especially can be very fast. Zooms are more complex and typically have smaller maximum apertures. Depending on the design, the maximum aperture can vary across the zoom range, with aperture reducing at the longer end.

Shutter

The shutter determines the duration for which the film or sensor is exposed to light. Typically, this will be measured in fractions of a second, although when light levels are low this can extend to seconds, minutes or even hours. Whilst the shutter is open, any movement by the subject will be recorded as a blur. This might be the desired result, but it is more usual to have the main subject sharp.

Neither is it the subject that can move, but the camera itself is susceptible to small movements when it is handheld. It is more usual for exposures to be made at 1/125 or higher to avoid the risk of camera shake. The general rule used to be that the shutter speed should be at least as high as the focal length in use, as any movement induced by the user will be magnified by a long lens. 1/30 of a second might seem like a very short period, but it is surprising how much movement can occur with either the subject or the camera in such a brief moment.

Recent developments in image stabilisation have altered this to an extent. Small gyroscopes mounted either in the lens or the camera detect small alterations in the attitude of the camera and move a special element in the lens or the sensor respectively to compensate. All clever stuff that allows slower shutter speeds to be used, although this remains limited to fractions of a second and anything longer requires the camera to be supported during an exposure.

The more traditional way to prevent camera shake is through the use of a monopod or tripod. Since a monopod is inherently unstable, unlike its tripod counterpart, it is only suitable for the same exposure durations as image stabilisation. For long exposures, a tripod remains the only option unless an alternative convenient resting place such as a wall can be found.

When using a tripod, a method of actuating the shutter remotely is desirable. Even with a camera firmly mounted on a tripod, it is still possible to move the camera by pressing the shutter release and get an image burred by camera shake. Traditionally, this was achieved with a wired cable release for older film cameras, but with the introduction of electronics, remote cable releases have become the norm. Wireless releases are also available, but a wired one is preferable.

The longest shutter speed for most cameras is 30 seconds, but when light levels are very low this is not always sufficient. A wired release allows what is known a “bulb” setting where the first press opens the shutter and a second closes it. When there is not much available light to make an exposure, accurate timing of the period when the shutter is open becomes less critical.

ISO

Somewhat strangely, ISO is the acronym for International Organisation for Standardization. Not that it is necessary to know this, but it might just come in useful on a quiz night! Camera film is one of the standards regulated by ISO and it specifies the speed at which film reacts to light. Without this information, it would be impossible to calculate the correct aperture and shutter speed values for an exposure.

Unlike f numbers, the ISO scale has a more logical progression. Low numbers such as ISO 100 denote a slow film and higher numbers such as 1600 faster ones. In common with f numbers, doubling or halving the number signifies that the film is twice or half as responsive respectively.

Thus ISO 200 is twice as fast as ISO 100, while ISO 400 is twice as fast as ISO 200 and four times as fast ISO 100.

When digital cameras were introduced, it made sense to extend the ISO standard to sensors. It was understood and ensured consistency and continuity for those making the transition from film. Digital users benefit enormously from the facility to change instantly the ISO speeds of their cameras when faced with fluctuating light conditions. The film worker has to hold a range of stock for any situation they are likely to encounter and is faced with wasting film if circumstances are not appropriate for what is loaded in the camera at the time.

Whilst changing the ISO on a digital camera is convenient, it is normally best to leave it on one of the lower settings. Increasing the ISO value reduces the amount of light required to record an image, but to do this the signal has to be amplified by the camera's circuitry. This means that any imperfections in the signal are magnified and manifest themselves as noise, which are random specks and colours that do not belong with the image. There are numerous applications that can remove noise, although this is always at the expense of losing some of the detail.

Digital SLRs usually perform well up to ISO 400 and the latest cameras beyond that. The technology is still developing and manufacturers are constantly introducing improvements. There are numerous camera review sites on the web and examination of these will indicate how your camera will perform at higher ISOs. Digital compacts fare less well due to their smaller sensors. That said, if the difference between getting an image or not at all, the higher ISOs are useful in an emergency.

Stops

Each step in the adjustment of speeds to double or halve an exposure value is often referred to as a stop, the term being a relic of the Victorian era at the dawn of photography. Originally, when cameras were much simpler, it referred just to lenses and altering the aperture was the only control the photographer had. These days, it is also used when referring to adjustments for shutter speed and ISO.

Using Shutter Speeds Creatively

There are many reasons to alter shutter speeds. A fast moving object could become blurred at lower speeds and slow speeds are frequently used to give running water a soft cotton wool like effect' foe example. Movement blur is not always a bad thing and when a moving subject such as a runner or car is totally frozen by a high shutter speed, the results can look very static. A sense of movement will be conveyed if there is some blurring in the athlete's limbs or the vehicle's wheels.

There is another technique called panning, where a shutter speed as low as 1/30 or 1/15 is set. When the shutter is pressed, move the camera in the same direction as the subject so that it stays in the same place in the frame. It takes practice to perfect, especially with a DSLR where the mirror blanks out the viewfinder during an exposure. When it works, the subject will be sharp with the blurred background implying movement. If using a lens or camera with image stabilisation, set it to detect camera movement in the vertical plane only, otherwise the system will attempt to make unwanted corrections as the camera pans horizontally.

This image was taken with a shutter speed of 1/15th second, which has caused blurring to the figures on the left and given them a sense of movement. That the rest of image is sharp in this handheld shot is due to the camera's inbuilt image stabilisation.

Using Aperture Creatively

All lenses have a characteristic known as depth of field, in which objects in front of and behind the point of focus appear acceptably sharp. The exact amount depends on a combination of the distance of the focus point from the lens, the focal length of the lens and the aperture set. Depth of field increases with short focal lengths, small apertures and distance. It decreases with long focal lengths, wide apertures and short focussing distance. Thus a wide-angle lens will exhibit good depth of field even at wide apertures, whereas a telephoto will have a shallower one despite using a small aperture.

A landscape photographer will normally want to get everything in the picture sharp, so will set a small aperture. A wide aperture, particularly on a long lens, is useful for rendering an unwanted background out of focus so that it does not detract from the subject. Another use is differential focussing where part of the image is rendered sharp and is contrasted by another part of the scene at a different distance, usually in the background, which is out of focus but still recognisable.

One area where problems can occur is in macro work, where even at small apertures depth of field can often be measured in millimetres. Unless the subject itself has a narrow plane, some areas will inevitably be out of focus and some care is necessary that this does not occur in a way that will distract from the final image. When it comes to composition, there are no hard or fast rules a wide aperture for a macro shot can concentrate the viewer's attention on the part of the subject that the photographer intends.

Extensive depth of field works best with digital compacts as the sensors in these cameras are so small that they have lenses with short focal lengths. This results in a large depth of field at all apertures and focal lengths. DSLRs often have depth of field preview facility, which is achieved by stopping down the lens to the chosen aperture to allow the user to gauge the depth of field effect. The benefit is somewhat abated as the viewfinder goes very dark making it difficult to gauge the effect. This does not happen with the newer hybrid type since the signal to the electronic viewfinder is boosted to compensate.

One further reason for varying the aperture is that very few lenses perform at their best when wide open. It is normally best close the aperture by a couple of stops to improve image quality, which means that many zoom lenses perform best between f8 and f11.

Finally, it should also be remembered that there is a direct correlation between aperture and shutter speed. If a small aperture is set, the shutter speed will have to be slower, whereas a wide aperture means that shutter speed can decrease. This ensures that amount of light entering the lens to make a correct exposure remains the same.

The use of a long telephoto lens shot at its maximum aperture of f/4 has rendered the distracting background out of focus, which focuses the viewer's attention on the kestrel.

A wide-angle lens and small aperture (f/10) has ensured a wide depth of field, so that the image is sharp from back to front.

Hyperfocal Distance

A consequence of the depth of field phenomenon is that when an image requires objects both near and far to be sharp, it is possible to set the point of focus midway. This is a technique often employed when shooting landscapes, as one example.

Since depth of field varies by focal length of the lens and aperture, the point at which the lens should be focussed to get everything sharp will vary. Some cameras have a control to work this out automatically, but normally the lens will have to be set to manual focus to prevent the focus automatically switching to the point selected by the autofocus system.

When most lenses were primes, it was usual to have markings indicating depth of field, which facilitated setting focus to the required hyperfocal distance. Since this becomes more difficult to show with a modern zoom lens with variable focal lengths, the tables below show the hyperfocal settings for a variety of focal lengths and apertures. All values are in feet.

Hyperfocal Distance for Crop Sensors

Focal Length	12	15	17	20	24	28	35	50	70	100	135
Aperture f/8	3.2	5	6.4	8.9	12.6	17	27	55	105	218	295
f/11	2.3	3.5	4.5	6.2	9	12	19	39	75	155	280
f/16	1.7	2.5	3.3	4.4	6.4	8.6	14.5	27	54	110	198
f/22	0.9	1.2	2.3	3.2	4.5	6	9.5	19.2	38	77	140

Hyperfocal Distance for Full Frame Sensors and 35 mm Film

Focal Length	16	20	24	28	35	28	50	70	100	135
Aperture f/8	3.8	5.6	8	11	17	17	27	55	105	218
f/11	2.3	3.5	4.5	6.2	9	12	19	39	75	155
f/16	1.7	2.5	3.3	4.4	6.4	8.6	14.5	27	54	110
f/22	0.9	1.2	2.3	3.2	4.5	6	9.5	19.2	38	77

Using the Camera Controls

Setting the shutter and aperture controls is by one of three main methods.

- Cameras usually have two means of setting both shutter and aperture for itself, with one being totally automatic which prevents the user from making any alterations. Clearly this is of little use to anyone who wishes to exert command over the camera to achieve a particular aesthetic effect. For this reason, there is also a Programme mode, which allows the aperture to be altered with corresponding changes to the shutter speed.
- More useful are the aperture and shutter priority modes that allow the aperture or shutter to be fixed and the camera makes the corresponding adjustment to the other component in setting the exposure. The photographer has the full benefit of flexibility and automation whilst retaining creative control. In situations where the photographer feels that incorrect exposure will ensue, it is possible to specify an adjustment to modify the settings determined by the camera.
- The last way is manual exposure, fixing both aperture and shutter without possibility of alteration by the camera.

Fully manual operation is how it always used to be done and brings us back to where we started at the beginning of this article, where the question was posed as to the benefits of automation.

Technical developments have certainly brought photography a long way, especially over the last few years with the advent of digital imaging. It has always been the case that manufacturers have strived to make their products as simple to use as possible, albeit in the past the methods used were less sophisticated than we are used to nowadays. Many are content to leave their cameras in a fully automatic mode, but for those who want to take their photography further an understanding of photographic principles remains essential.