Week 3
Shutter Speed and ISO

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SHUTTER SPEED

Exposure time

In a previous section, we looked at taking control of Aperture as a first step in creative control.

We now take the next step by taking control of the exposure time of our images, commonly referred to as Shutter Speed. Shutter speed refers to the amount of time that the camera shutter is open to allow light through to the sensor or film.

A "fast" shutter speed refers to a short exposure time. A "slow" shutter speed means a longer exposure time.

Shutter Speed and Exposure

Shutter speeds are measured in seconds, or fractions of a second. If we begin at 1 second and slow our shutter speed down, each stop is measured as a doubling of time.

1, 2, 4, 8, 16, 32

It is worth pointing out that your shutter speed in manual and programmed modes has a maximum exposure time of 30 seconds, not 32 seconds.

Conversely, when increasing shutter speed, each time value is halved.

1,1/2, 1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000 …

Did you notice the discrepancy between 1/160 and 1/125? The values, while doubling or halving are generally a "rounded up" value. There is a mathematical reason for this but it's easier to just accept that at some point there is a "leap year" across the full stop differences.

While these represent a full stop of difference to the exposure triangle, your camera will present you with 2 or 3 stops in between the full stop of light.

Why control exposure time?

Apart from being used as one of the variables in the exposure triangle to achieve correctly exposed images, it allows us to control the character of our images and open a completely new range of possibilities. Controlling shutter speed also allows us to prevent blurry images arising from camera shake.

Camera shake

When hand holding a camera, it is inevitable there will be a degree of camera shake.

Combined with good camera handling technique using a shutter speed appropriate for the focal length of the lens can eliminate any visible evidence of this movement.

As a rule of thumb, setting the shutter speed to the reciprocal of the lens focal length. For example, using a 30mm lens you would set the shutter speed to 1/30 of a second or faster, or using a 200mm lens you would use 1/200 of a second or faster. Any slower and motion blur is likely to occur.

Handheld shot taken using 400mm lens at 1/200 second without image stabilisation, showing results of camera shake.

(Shutter slower than 1/400th second)

Image Stabilisation

Some cameras and lenses include image stabilisation.

Claims of "3 stops" or "5 stops" of stabilisation can vary and it of course comes down to practicing and finding out how well the stabilisation works for you.

It is worth remembering that Image Stabilisation does not help freeze your subject moving.

Shutter Preferred

In Shutter Priority (also referred to as shutter preferred) mode, we set the shutter speed on the camera, the camera measures the light and sets the aperture.

On most cameras, this is the S setting on the mode selection dial. On other cameras, it is the TV (time value) setting. If these settings are not evident then it will be somewhere in the menus.

The emphasis now moves away from depth of field and onto a consideration of what we wish to capture in a set slice of time.

More than any other type of photography, this is the technique in which pre-visualisation is most important. The trick that must be learned is to anticipate the effect of time on the image, as you cannot see the effect through the viewfinder.

Our thinking changes in the direction of what can happen in one four thousandth of a second or one eighth of a second and how this time interval will be depicted in the image.

Why Use This Technique?

The phrase "stopping the action" refers to a photograph that uses a fast shutter speed to trap a short time interval in which there is almost no movement of a subject. In sport, we might be capturing the instant when the ball is on the bat, the instant when the weight is lifted, or the javelin released from the hand. In landscapes, we might capture every drop of a splash of water stopped in time.

Slow shutter speeds are used to show the motion of an object or to imply action. You might be able to capture the elegance of movement of a dancer with a one-second exposure or show the flutter of the wing tips of a hawk at one fifteenth of a second.

Longer (slow) exposure times might allow you to produce star trails in landscapes at night or the tracks of the lights of vehicles moving along a freeway. The smooth milk-like appearance of moving water is easy to achieve with shutter speeds around half a second (and a tripod).

When you're shooting at speeds slower than you can steadily hold by hand, besides finding a steady surface to rest your camera on, a tripod becomes a necessary tool.

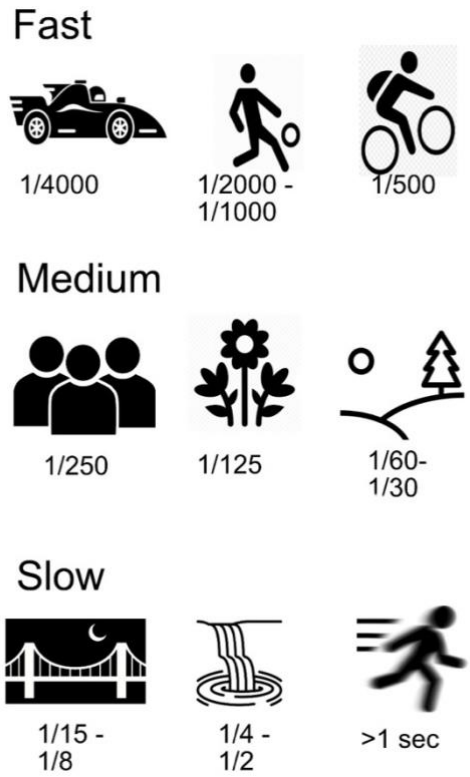
This won't help freeze moving subjects of course but if shooting a still subject it may end up being your only option and, in many cases, opens a whole new level of creativity.

From shooting sunrise or sunset, waterfalls and seascapes, cityscapes, and fireworks, when the light gets low, a tripod is a valued asset.

Changing the time interval means that light will reach the sensor so the camera will change the aperture to compensate. The point is that we still have control over the aperture; it is just a bit indirect.

However, in every case we need to be aware that the camera is choosing a lens aperture for us. The choice might not be exactly what we want so it is a good idea to review every shot on the screen and adjust accordingly.

A quick guide to which shutter speeds we use for different subjects



Benefits Of This Approach

Photography is a two-dimensional representation of a three-dimensional world.

Since we live in three dimensions of space and one of time, it is not surprising that we often try to build a third dimension back into our photographs.

We have two ways of doing this. If we use aperture preferred automatic mode it invites us to look at the illusion of depth in our images and "compose for depth". If we use shutter priority mode, then this invites to think about the size of the slice of time that we wish to depict and "compose for time".

In both cases, we can reclaim a lost dimension. In both cases, we can add impact and character. Using this extra dimension allows an image to tell a story.

ISO

As well as shutter speed and lens aperture, a third quantity that can be set on your camera as a means of determining exposure values.

In film photography, different films have different degrees of light sensitivity that affect their speeds of reaction when exposed to light.

The speed of how film reacts to light is measured by what is known as ISO (International Standards Organisation) sensitivity rating. Digital cameras operate using the same ISO scale as their film counterparts.

Typical values for ISO are ISO 100, ISO 200, ISO 400, ISO 800, and so on, note that these change as do aperture and shutter speed, in 'Stops'. Some cameras will allow intermediate values, such as 160, 2320, or 500, to be set also.

For a perfect exposure, the sensor must receive a certain exact amount of light. As the ISO number increases, the sensor system becomes more sensitive to light and therefore requires less light for a correct exposure. This influences the camera's choice of shutter speed and/or lens aperture to compensate for the change in sensitivity.

For example, changing 100 ISO to 200 ISO will double the sensitivity to light, now you need half the amount of light to properly expose the image. Changing further, from 200 ISO to 400 ISO will again double the sensitivity.

A typical digital camera will be set at ISO 100 or 200 as it comes out of the box. This is a useful setting for general photography. However, you might find yourself in a low-light situation where you have low shutter speeds and flash is inappropriate. In this case, it is appropriate to increase the ISO rating on your camera to get back your faster shutter speeds. Indoor sports photography, candid portraiture and some types of wildlife photography are typical cases in which you might need your camera to be more sensitive to light so that you can work with reasonable shutter speeds.

In other circumstances, you may wish to work with increased depth of field without changing shutter speed. Increasing ISO will make the smaller apertures accessible.

The ISO values fit into the "doubling and halving" pattern that relates shutter speed and lens aperture. Doubling the ISO rating will halve the amount of light required for a perfect exposure.

For example, if you had a shutter speed of 1/60 sec with 100 ISO then you would require a shutter speed of 1/125 sec with 200 ISO or a shutter speed of 1/250 sec with 400 ISO.

Changing the ISO value can also be very handy in combination with flash. Setting a higher ISO value increases the range of the flash: or to make it more correct to make the camera more sensitive to whatever light bounces of the subject and back to the camera.

The trade-off of higher ISO levels – The by-product of signal amplification is “noise” or “grain”. Noise is more visible in shadow areas as well as in sections consisting of a uniform colour such as blue sky, loss of fine details and poorer colour reproduction. Compact cameras and ultra-compact cameras are the ones that exhibit the most noise. (See the next topic ‘Noise’ for further information.)

Auto ISO

Auto-ISO allows the camera to choose an appropriate ISO level within a defined range – daytime or sufficient light available the camera will select a low ISO, but when the lighting conditions are not favourable the camera automatically chooses a higher ISO.

Advice

To get the best possible results from your camera, find the “native" ISO for your sensor. You can find this in your manual. Then set your camera to aperture preferred automatic mode and set the aperture to f/5.6 or f/8 (two or three stops down from wide open). The lens will have a "sweet spot" somewhere around these values. Then set your image quality to RAW. This strategy will give you files of optimum quality.

At the time of writing, most cameras will give you good quality files at ISO 1600 and the more expensive cameras will extend this to ISO 6400. Very expensive cameras will offer ISO ratings over 200000 for photographing black cats in coalmines.

The discussion has been primarily about increasing ISO to deal with situations where more light is needed. What if you want less light? For example; on a bright sunny day you want to use a large aperture to get shallow depth of field, you also want to use a slow shutter speed to emphasise the movement of your subject. Some cameras have a low ISO setting; however, this only lowers it by one stop.

If you need more than this, you will use what is called a Neutral Density Filter. This is a filter that attaches to your lens that reduces the amount of light coming in and does not cause any colour cast (hence Neutral), some can reduce incoming light by up to ten stops.

Technical Explanation

Digital sensors have only a true ISO rating up to 200 ISO, and to simulate higher ISO equivalents, the signal output of the sensor has to be amplified. When a very high ISO value is set in response to low light levels, the signal generated by the light reaching the sensor may get close to the same level as the background noise in the sensor (primarily due to heat of operation). At this point, the signal to noise ratio is low, and strangely coloured pixels may result.

The method and degree to which sensors manage noise is one of the key discriminating factors in the cost of camera bodies.

DIGITAL NOISE

Introduction

Digital noise is a term given to pixels in an image that are not the colour that they should be, they appear as speckles and are best seen in darker regions of the image.

There are three main sources of digital noise:

A cell in a sensor works by reacting to light reaching the surface. When a photon of light hits the cell surface, electrons are released to create a current; it is the magnitude of this current that indicates the amount of light. However, some electrons are also released due to heat effects, and these add in to the count, and this results in incorrect colour values. This is the thermal noise effect.

In some compact cameras, there are 12 million or so cell sites on the sensor surface. These all cram into an area about the size of your little fingernail. With such a small area to hit, only a few photons of light might hit a cell and then the colour is being determined from very little data. If the sensor is physically larger, then the light gathering capacity is greater and there is a higher chance of an accurate reading. This is an amplification effect.

When we increase the ISO setting, we are not gathering more light, we are simply taking the cell readings and multiplying them by a factor to compensate for the low light levels. It is these low light levels that have the highest inherent inaccuracy due to thermal effects (see above) and as we multiply the data, we also multiply the errors they carry with them. This amplification effect is like the hiss on a radio broadcast.

The overall effect of these sources is to have pixels of the wrong colour in the image.

The worst case occurs with physically small sensors with high megapixel counts. If we are also using a high ISO rating then things can start to look ugly, first in the deep shadow areas.

The best case is to have a physically large sensor with a moderate megapixel count and operating at the “native” ISO rating.

Always Noise

Noise is a random factor in every image, but it can be dealt with to a degree in software. Look for the phrase *noise reduction* or *noise control* in your software. You will probably find it in the ‘Filters’ menu. This software will try to reduce the effects of noise by working out what colour the pixel should be.

There are software products that specialise in the control of noise. Some of these take the issue very seriously, do a very good job, and cost a lot.

Removing Noise

There are quite a few approaches taken to mitigate the effect of digital noise. The simpler methods scan the image for anomalous colour values by comparing each pixel with four or eight closest neighbours. If the colour value is too different then it is given the average colour of the neighbours.

This works well for some types of images but can smooth our sharp edges that you might want in your image.

Other methods find noisy pixels and look at the neighbours. They then fit polynomials to this data set and create a new colour for the dodgy pixel. This works well and is the same sort of algorithm that is used to upsize and downsizes images.

There is some noise in every image. If it is a small amount, then software can make it almost invisible. If there is a large amount, then there will be residual effects.

Recent improvements in AI noise removal have introduced a new generation of noise removal tools. This is an area that is moving rapidly, and the results are quite amazing.

The best results in noise removal will always be seen when using RAW files instead of JPG files.