Getting the Most Out Of Image Stabilisation - Simon Pelling

All of us have experienced the frustration of capturing that perfect moment, only to find once we get it back to the computer, that the image is just blurry enough to be useless because the subject has moved or we have not held the camera steady. These problems are magnified by the long telephoto lenses typically needed to photograph birds. Fortunately for us, over the last couple of decades camera companies and lens manufacturers have developed highly effective mechanical image stabilisation systems that help overcome the problem of camera movement.

Nowadays, image stabilisation is pretty ubiquitous. Even the very basic, low quality kit zoom that came bolted on to the front of my Canon DSLR when I bought it includes image stabilisation which is remarkably effective. Indeed for some cameras, including certain mirrorless models as well as compact and superzoom cameras, it can be fiddly to turn it off. Many photographers pretty much take stabilisation for granted, and leave it on all the time.

However, as with any technology in digital photography, it pays to understand a little about how it works, in order to be able to use it effectively, and indeed to know whether and when to turn it on or off. There is lots of information on image stabilisation online, some of which can be confusing, or use catchy and often meaningless promotional phrases. In this article I will attempt to provide a clearer understanding of its operation and effectiveness.

Please note that this article is primarily aimed at the stills photographer. Image stabilisation is also important for the use of cameras in video mode, and indeed many of the innovations in this area have been (and still are being) driven by the challenges of keeping video recordings steady – but this is not my primary area of interest. Many models of interchangeable lens cameras, particularly mirrorless, are as much intended for high quality video work as they are for still photography work.

Stabilising the Image the Old-fashioned Way – the 'Reciprocal Rule'

Of course, people wanted sharp photos before mechanical methods of image stabilisation existed. To do this, the photographer needed to either support the camera firmly, or to shoot at a fast enough shutter speed to freeze the movement of the camera and lens.

There is still no substitute for a tripod if you want to keep the camera perfectly still. However, as we all know, it is often not feasible to carry and use stout tripods in the field for bird photography.

It is virtually impossible to hold a camera absolutely steady when holding it by hand, and the effects of camera motion on the image increase with the focal length of the lens. Over time, film photographers developed the 'reciprocal rule' for using 35mm film which is that, *when hand-holding a 35mm film camera, one should use a shutter speed which is the inverse of the lens focal length* (1/focal length in mm). Thus, for example, if you had a camera with a 200mm lens, the slowest shutter speed you should use to still get sharp photos is 1/200s. Of course, this was only ever a guide, because some people can hold a camera steadier than others.

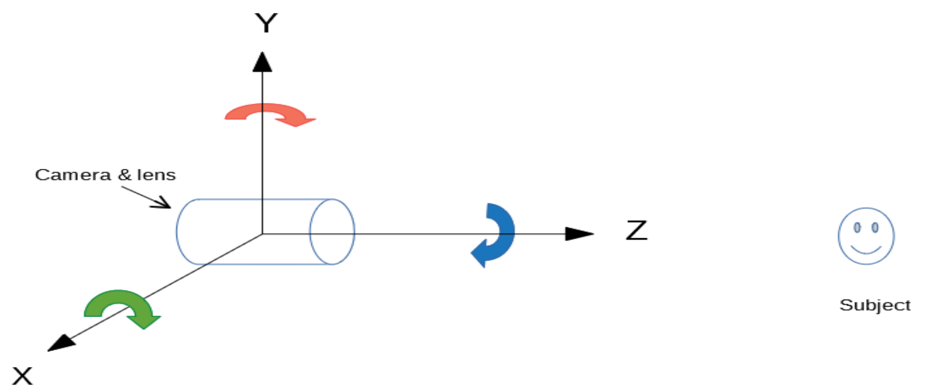
In digital photography, this rule can still be used but it needs to be adjusted for sensor size. Remember that the smaller the sensor, the smaller the field of view (i.e. the scope of what you see through the viewfinder) for a given lens. In effect, an APS-C sensor camera with a 400mm lens will have approximately the same field of view as a full-frame camera with a 600mm lens, due to the relative sizes of the sensors. The smaller APS-C sensor makes the lens *appear* as if it is a longer telephoto, by a factor of 1.5[i], with all the associated additional problems of camera shake. This is often referred to as '600 mm equivalent' even though, of course, the focal length of the 400mm lens does not change.

As a result the reciprocal rule must be adjusted for the smaller APS-C sensor. Whereas the full frame camera (with a sensor the size of 35mm film) the "1/focal length" is still correct, for an APS-C camera such as the Nikon D500 or Canon 7DII, the reciprocal rule is "1/focal length multiplied by crop factor". With a 200 mm lens the slowest hand-held shutter speed needs to be about 1/300s (or the nearest equivalent available).

The problem with simply relying on the reciprocal rule is that other things must be compromised in order to keep the shutter speed high. In lower light it will be necessary to either use a wider aperture (which reduces depth of field, and may simply not be available on some zoom lenses with a maximum aperture of f/5.6 or f/6.3) or higher ISOs (which can bring about image degradation due to noise). These issues are amplified with long telephoto lenses.

How Image Stabilisation Works

The objective of image stabilisation is to keep the image steady on the sensor of the camera. A hand-held camera and lens can move in multiple ways in three dimensions - from side to side, up and down, and rotation around the central axes of the body and lens (see box below). Image stabilisation systems use highly sensitive methods of counteracting these movements.



The engineering challenges of stabilisation are substantial. An object (camera) moving in three dimensional space will move in relation to three axes, as well as three types of rotation, creating a complex set of directions of movement to be corrected by image stabilisation systems. These include:

- *X-shift: horizontal side-to-side movement of body and lens*
- *Y-shift: vertical up-down movements of body and lens*
- *Roll: rotation of the camera around the axis of the lens (blue arrow)*
- *Yaw: side to side 'waggling' of the lens around the Y axis (red arrow)*
- *Pitch: up and down 'dipping and rising' of the lens around the X axis (green arrow)*

Note: the camera and lens also move towards and away from the subject (Z-shift). However as this is primarily dealt with by the focus of the lens and its depth of field it is not corrected in image stabilisation.

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[i] This is the *'crop factor'*. Nikon, Sony, Pentax, and Fuji all use APS-C sensors with a 1.5 crop factor, but Canon uses a slightly smaller APS-C sensor with a crop factor of 1.6. Olympus and Panasonic Micro Four Third sensors have a crop factor of 2.

There are two basic methods by which stabilisation is achieved: move part of the lens, to move the path of the light so that the same image always projects onto the sensor (*lens-based stabilisation*); or move the sensor to match the movement of the camera body (*sensor-based stabilisation*). A few cameras use both systems together.

Image stabilisation systems are called different things by different manufacturers. Canon and Olympus use Image Stabilisation (IS), Nikon uses Vibration Reduction (VR), Sony uses Optical Steady Shot (OSS) or Mega Optical Image Stabilisation (MegaOIS).

Lens-based Stabilisation

Lens-based stabilisation has historically been the primary system for Canon and Nikon DSLR systems, although this is changing with mirrorless systems. Lens stabilisation is also used by a range of other manufacturers, and third party lens manufacturers such as Tamron and Sigma also produce a range of stabilised lenses for many camera mounts.

Lens-based stabilisation involves shifting a part of the lens at right angles to the central axis of the lens, to compensate for camera motion. One or more glass elements of the lens are mounted on a system of brackets which can be moved many times per second. When the shutter button is half pressed, motion sensors detect the direction of movement; the moving element is unlocked and the movement compensation mechanism is activated. It continues through the opening and closing of the shutter, and for a short period after the shutter button is released.

Apart from the obvious result of stabilising the image recorded, lens-based systems have one very significant benefit in that they steady the observed image in the viewfinder in DSLRs. This makes photography more comfortable generally, and enables accurate positioning of focus points and exposure points (e.g. if one is using single point autofocus and spot metering). Camera manufacturers and internet commentators also claim that lens-based systems are better at stabilising long telephoto lenses, and can also be programmed precisely to match the focal length and other characteristics of a particular lens. The downside of this is that every lens needs its own separate system, which adds cost and, potentially, weight to each stabilised lens.

Sensor-based Stabilisation

Sensor-based systems (sometimes abbreviated to In Body Image Stabilisation or IBIS) have been the mainstay of the image stabilisation systems adopted by Sony, Pentax and Olympus, although as with lens-based systems, manufacturers are increasingly adopting both methods in different systems.

Sensor systems have the sensor mounted on a flexible mount enabling it to move. Similar to lens-based systems, the camera includes movement sensors, and actuators to move the sensor to compensate for movement of the camera body. In early systems the sensor moved in the plane of the shutter ie from side-to-side, horizontally and vertically. More recently, quite sophisticated systems have been developed by several manufacturers which also allow movement of the sensor in ways which compensate for the rotational movements (roll, yaw and pitch).

These systems have been claimed to be less effective for very long telephoto lenses, although the latest systems in advanced camera bodies by (for example) Sony and Olympus appear to have become better at addressing this. In DSLRs, IBIS systems don't steady the image in the optical viewfinder because there is no change to the path of the light through the lens. However, most cameras using IBIS now are mirrorless cameras. In these cameras, IBIS *does* steady the electronic viewfinder image, because that image is read off the stabilised main sensor.

Because the mechanism is in the body, IBIS works for any lens attached to the camera. This includes older lenses which were made before image stabilisation was developed. Lenses can potentially be cheaper and lighter, and have no moving lens elements. The sensor moving mechanism can also be used to clean dust – e.g. a number of Sony cameras with sensor stabilisation physically vibrate the sensor when the camera is turned on and off to minimise dust accumulation. Some brands have also adopted a method whereby a very detailed image can be taken by the camera, moving the sensor slightly between each exposure and them combining several exposures into a single image.

How Effective Is Image Stabilisation

Over the years, image stabilisation systems have undergone significant improvements. Developments in computational systems in cameras and in microelectronics have greatly increased the sensitivity of image stabilisation. Other innovations allow these systems to respond automatically to different situations such as different types of motion of the camera, and to distinguish movements like panning from random camera shake. Advanced mirrorless systems increasingly are able to combine in-body systems with in-lens systems for particular camera-lens combinations, still further increasing the ability to deal with different types of camera movements. This requires both lens and body to be able to operate together in sophisticated ways, meaning such systems are currently mainly limited to combinations of lenses and bodies by the same manufacturer.

One of the main methods used by camera manufacturers to report the effectiveness of image stabilisation is to quote the number of stops of shutter speed reduction that the system enables, in order to still get a sharp image. For example, Olympus on its web site claims that its 300mm f/4 IS Pro lens can achieve the equivalent of 6 shutter speed stops of stabilisation when attached to particular Olympus bodies. Similarly, Canon typically claims up to 4 shutter stops of stabilisation for a number of its lenses such as the EF 100-400 IS II USM.

What this means in practice is that if one needs a shutter speed of 1/800s to get a sharp image with a particular lens *without* stabilisation, one would (in theory) be able to get a sharp image at about 1/50s *with* stabilisation if that lens has a 4-stop stabilisation system.

These claims must be taken with considerable caution. As Canon makes clear in a fairly detailed explanation on one of its websites (snapshot.canon-asia.com/article/en/lens-faq-3-how-are-image-stabilization-stops-determined), the shutter stop figure is determined using a standard laboratory testing procedure using an artificial source of vibration. Canon is at pains to say that testing does not involve real world tests, and the published number may not match the actual benefits achieved by a user in the field. In addition, a search of other camera models suggests that in a number of cases the shutter stop claims in promotional material are subject to 'small print' caveats which might or might not affect real world experience.

Ultimately, whether you as a photographer will be able to achieve a particular level of benefit from image stabilisation will depend on your own capacity to hold the camera steady as well as other environmental factors (eg wind, external sources of vibration such as a motor etc) and the capacity of the stabilisation system to compensate.

Canon also claims that its image stabilisation is effective with movement from 0.5 Hz to 20,000 Hz. (1 Hz = 1 cycle per second. Human movement, according to Canon is typically 0.5-3 Hz. Engine vibrations may be 10-20,000 Hz).

For those who want to delve further into particular systems, a search of individual manufacturers' web sites can often turn up explanations of their stabilisation systems, with accompanying video and diagrams. One such explanation from Canon can be found at: cpn.canon-europe.com/content/education/infobank/lenses/image_stabilisation.do. For an explanation of Nikon's VR system see: www.nikonusa.com/en/learn-and-explore/a/products-and-innovation/vibration-reduction.html (and links within).

Understanding the System in Your Camera

As noted at several places above, different manufacturers implement their image stabilisation systems in different ways. For optimal use, it is important for the user to understand the operation of the particular system used by the camera and lens they use.

Users of Canon systems (the largest group of Birdlife Photography users) will know that more upmarket Canon lenses have multiple modes of image stabilisation, which are optimised for different photographic situations. These are engaged through a switch on the lens itself.

- Mode 1 is a general mode for still photography. It engages the full range of image stabilisation, in both X and Y axes, and provides a stable, steady image in the viewfinder. However, one issue with Mode 1 is that it interprets *desirable* camera movement, such as panning to follow a flying bird, as *unwanted* camera motion, so it attempts to compensate. The user will find they have difficulty following the movement of the subject, with the viewfinder view seeming to be quite jerky.

- Mode 2 is for panning. The camera detects the direction of panning, and switches off image stabilisation in that direction. For example, with a horizontally moving subject, image stabilisation in the horizontal direction will be suppressed, but will be retained in the vertical direction.

- Mode 3 combines elements of Mode 1 and Mode 2, and according to Canon was implemented to enable tracking of fairly random movements such as sports action. When engaged through a half shutter button press, the stabilisation mechanism is spooled up but the actual movement of the stabiliser lens element does not occur until the moment the shutter is fired. In this way, tracking of the subject is not interfered with, but the user gets the benefit of stabilisation at the time the shutter is opened.

Nikon has a broadly similar set of modes designed for different situations. These include a Normal mode, a Sports mode (also called an Active mode) and a mode designed for tripods.

I am not familiar with mirrorless models such as recent high end Sony and Nikon cameras, which can use both in-body and in-lens stabilisation. However, recent advanced mirrorless cameras by Sony include advice in the manual that Steady Shot can be set automatically if the camera and lens are able to communicate effectively, or manually by entering the lens focal length. This helps optimise the sensor movements for the focal length. Sony also recommends that Steady Shot should be turned off if a tripod is used. In-lens systems for Sony lenses seem to have similar switchable settings to Canon's. In-lens stabilisation may not always be compatible with sensor-based stabilisation, and users should check whether in-lens stabilisation should be set to Off when used with a sensor-stabilised body.

Image stabilisation takes a short period of time to start and achieve optimal stabilisation. Modern systems now do this in less than one second, but if circumstances allow it is probably still optimal to allow a short time for the stabilisation to fully adjust to the camera motion before taking the shot.

Using Tripods

The rule of thumb, at least until recently, has been that stabilisation systems should be turned Off if the camera is used on a tripod. I understand this is because the system can develop a feedback loop if there is no camera movement to compensate for, applying compensation where there no need for it and reducing sharpness. However, Canon now advises that 'later' lens models automatically detect if a tripod is being used, and react accordingly. They still advise that older lenses should have their stabilisation turned off on a tripod, but note that there are circumstances (eg strong wind) where even on a tripod there will be some camera movement and in these situations it is beneficial to keep stabilisation on. Stabilisation can also be used when a monopod is used, or other support system such as a beanbag where there is still a risk of movement.

As noted above, Sony still appears to recommend that stabilisation be turned off on a tripod, and Nikon has a 'tripod mode' for use with tripods. If you use a different make/model, I recommend you check with your manual or the product manufacturer’s web site before using a tripod.

Movement of the Photographic Subject

To state the obvious, image stabilisation is a solution only to the problem of camera movement. It does not, of course, affect subject movement. To freeze subject movement there is no substitute for a fast shutter speed. The photographer will still need to make conscious decisions about the minimum shutter speed desirable for a particular situation.

This is particularly true if the photographer uses a camera mode in which the camera automatically adjusts shutter speed, such as Aperture Priority. There is a risk that users become taken in by the steady picture in the viewfinder that stabilisation produces, and stop thinking about the shutter speed needed for the photographic subject. In low light situations the shutter speed might drop to levels well below those needed to freeze action, but the image still appear to be nice and steady in the viewfinder due to the stabilisation. The result will be that the photographer gets nice sharp images of (for example) the branch the bird is sitting on, but a blurry or partly blurry bird.

With a 400mm lens on an APS-C camera, which gives a field of view equivalent to 600mm on a full frame camera, I have found that for birds moving steadily through the undergrowth, a speed of around 1/800s or higher is needed to be reasonably confident of freezing motion. Getting sharp pictures at lower shutter speeds is certainly possible, and using a high speed continuous shutter mode to take lots of photos will help in getting at least some sharp frames. I find that birds in flight require shutter speeds of more than 1/1000s.

Should Image Stabilisation Always Be Left On?

Generally I advocate that automated and ‘intelligent’ functions of cameras and lenses are fine to rely on as photographers, but that *one should understand what the function is doing and why*. In this way, the photographer stays in control, not the camera. This applies to image stabilisation. Many manufacturers seem to assume (probably correctly) that most general photographers will default to having stabilisation always on, particularly if the manufacturer requires one to dig into the menu to change the default setting. But is this the best approach?

Stabilisation is ultimately a technical solution to a problem. If the problem doesn't exist (or is already compensated for by other means such as shutter speed), at best it does no harm, but it does not add any value to picture sharpness. In these situations, it will only add wear and tear to moving parts, and consume battery charge (which might be significant with some mirrorless cameras). The old 'reciprocal rule' is still valid. The point at which stabilisation becomes unnecessary will depend on the lens' focal length, the sensor size, and the user's capability. But are there situations (other than the use of a tripod noted above) where image stabilisation is actually harmful to image quality?

Image stabilisation involves moving, often at high speed, two critical elements of the photographic capture process (an element of the lens, and the sensor). Logically, there must be some capacity for this movement to impact on ultimate image quality, and this would be most visible at shutter speeds where the benefits of the stabilisation itself are neutralised. These effects might be more obvious in full frame, high pixel sensors, when the image is viewed at 100%. However, I have been unable to find much hard evidence one way or the other as to whether this is the case. Some internet commentators make claims about the impact of stabilisation on both sharpness and bokeh (the pattern in the out of focus areas of the photo) but I have not been able to find specific examples showing these effects in photos, or more detailed explanations. Camera and lens manufacturers appear to be largely silent on this issue.

If these effects exist, the chances are they are at a level which would not affect most of us in our everyday photography, particularly given all the other challenges in getting an acceptably sharp photo of an ideally posed bird! Also, there are other benefits of stabilisation, such as having a steady viewfinder image with a telephoto lens, which may be worth having even if the stabilisation mechanism itself has no benefit at the shutter speed being used.

If anyone has more detail on this, please share it.

Summary

To summarise, users could consider the following approach:

- Read the manual of your lens and camera (and perhaps research your brand's website) to understand how the image stabilisation system works and any do's and don'ts recommended for its use.
- Make sure you understand the operation of different modes of stabilisation available to you, and the situations in which to use them.
- Below 1/1000s most people will benefit from having stabilisation switched on at all times unless the camera is on a tripod.
- Above 1/1000s, it's up to you, but if you are continuously shooting in the high 1/1000s and above you probably won't see any sharpness benefit from stabilisation for most camera and lens combinations. The 'reciprocal rule' still works, but sensor size must be factored in. If left on, you will still get the (substantial) benefits of a steady or nearly steady image in the viewfinder.
- Focus on the shutter speed needed to freeze motion (if this is what you want to do), rather than how good your image stabilisation is at 1/50s!