INDIANA FORENSIC INSTITUTE
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Using Research, Consulting and Training to expand and enhance the use of imaging in law enforement and judicial proceedings.

DEPTH OF FIELD

When you take a photo, you focus the camera on some object that is at some distance in front of the camera, that we will call *D*. Other objects that are very close to the camera but in the field of view will be noticeably not well focused. Also, some objects that are far from the camera and beyond D, will also not be well focused. As close in objects become closer to the main object they will appear in increasingly better focus and at some point they appear to be as well focused as the main object. We call this distance, *D(n)*, or the near distance. A similar effect occurs as distant objects are closer to the main object. We call that distance, D(f), or far distance. The distance between the near and far distances is the depth of field. It is the range of distances in which all objects appear to be well focused.

There have been persistent anecdotes that people are finding that they are getting greater depth of field (DoF) with digital cameras than with their 35 mm film cameras. Is this real, or does it just appear to be that way. The answer is there is a real, scientifically-based reason why some, but not all, digital cameras would exhibit greater DoF. Assuming high-quality lenses and high-resolution cameras, there are four factors that control the DoF. First of all, and best known, there is the f/stop used. Larger f/numbers with their smaller apertures will result in greater DoF, all other things being equal (seritus paribus). All photographers know that. This is the result of the rays coming in at lower angles relative to each other. The second factor is the focal length of the lens, seritus paribus. The longer the focal length of the lens, the smaller will be the DoF. Again, this is common knowledge. By the way, macro lenses, and microscopes for that matter, have notoriously low DoF, but these are essentially telephoto lenses working in reverse. The third factor is where the lens is focused. If the plane of focus is far off, the system will have smaller DoF. Finally, there is the fourth factor, the one that is not widely known. The size of the image frame will affect the DoF. In a film camera, it is the size of the film image on the film. In a digital camera, it is the size of the active portion of the imager chip. Smaller frame sizes give greater the DoF. This is the key to the film / digital comparison.

Most digital cameras, especially the ones that are a few years old, have frame sizes that are smaller than that of a 35 mm film camera. This will result in those digital cameras having greater DoF. The newer, "full frame" digital cameras (DSLR's) will give DoF performance that is essentially the same as that of a 35 mm film camera. Now there are other reasons for wanting a larger digital imager in your camera, but DoF is not one of them.

For those few who want to know the physics, it goes like this:

The circle of confusion, *C* is given by:

$$C = \frac{d}{1730} \qquad (1)$$

Where *d* is the diagonal of the image frame. Next one can compute the Hyperfocal Distance, *H*. The Hyperfocal distance is that distance in front of the camera where all things beyond the plane of focus appear to be in focus and so do all those points half the distance to the plane of focus. This is the basis for single use cameras that do not have any focus adjustment. Simply make the Hyperfocal distance relatively short. For example, if H is set to 10 feet, than all things beyond 5 feet will appear to be in focus.

$$H = \frac{F^2}{f \times c} + F \qquad (2)$$

Where *F* is the focal length, *f* is the f/stop of the lens, and *C* is the circle of confusion. The next step is to compute the distances to the points at which the focus drops offs are noticeable – both the near and far distances. These are given by the next two formulae, in which D(n) is the near point and D(f) is the far point. *D* in these equations is the distance at which the camera is focused.

$$D(n) = \frac{H \times D}{H + D}$$

$$(3 \ \& \ 4)$$

$$D(f) = \frac{H \times D}{H - D}$$

Please note that the far distance can go negative starting when the point of focus is beyond the Hyperfocal point. The convention is to call all points which are at zero or negative as infinity. The final step is to subtract the near point distance from the far point distance. This gives the DoF.

One precaution in using these formulae is that there can be a mix up of units if one is not careful. It is not uncommon for the distances to be in feet and inches and the focal length and imager size to be in millimeters. Be sure to make adjustments to get all units consistent. These formulae are used in the DoF calculator on the IFI website. But be careful with units.

Going back to the start of this piece, there are four factors that control DoF and those factors are:

1. f/stop: This effect comes into play in equation # 2
2. Focal length: This effect comes into play in equation # 2
3. Distance to focal plane: This effect comes into play in equations # 3 and # 4
4. Imager size: This effect comes into play in equation # 1