Depth of Field

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What is Depth of Field?

The object your camera is focused on is in focus. In theory everything in front of, or behind, that object is out of focus. In practice there is a range in front and behind which is acceptably in focus. The “Depth of Field” is the range of distances, from the nearest to the furthest, which are acceptably in focus.

By controlling the depth of field you can choose whether the background is in focus or not. For a landscape you may want all distances to be in focus. For a portrait you probably want the background out of focus to concentrate on the face.

Deep Depth of Field

Shallow Depth of Field

Why Does Depth of Field Happen?

There are a couple of ways to understand why there are different distances which are in focus. They are both concerned with the aperture of the lens. That is, how big the hole is that the light is coming through.

Light Paths

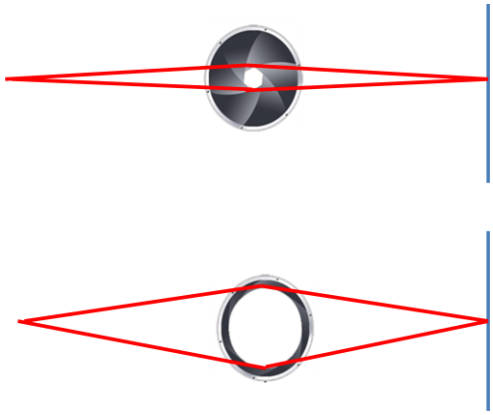
In the example on the right, light from something which is in focus will be in focus on the sensor whatever the aperture.

However, light from something further away will come to a focus before it reaches the sensor. Light which has passed through the larger aperture becomes more spread out on the sensor.

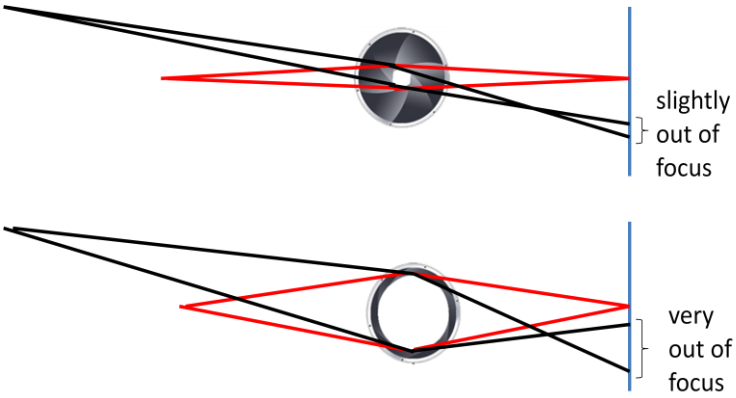
For the technically minded, light from a point source will create a circle of blur on the sensor. This is called the "Circle of Confusion". A large aperture produces a large Circle of Confusion. A small aperture produces a small Circle of Confusion.

To define depth of field, you set a limit of the acceptable Circle of Confusion. If it is too large then the image is out of focus.

If the Circle of Confusion is small enough, the image will appear to be acceptably in focus.



Light passing through different apertures to the sensor on the right.



Light from a different distance will be more or less out of focus depending on the aperture.

Different Viewpoints

Another approach is to think about what the subject looks like from different parts of the aperture. The aperture may be small, but it still has size. Because these viewpoints are slightly different, the views you get will be slightly different.

Imagine a chess set looked at from two different directions. This rather like looking at the chess pieces from the opposite sides of the aperture.

Two views of a chess set from slightly different directions

Now imagine the two views superimposed. I have imagined the King to be the point of focus. So both views have the same picture of the King: the images coincide.

Two Viewpoints Superimposed

The Queen is close to the King so the images nearly coincide. The Bishop is further away still: its images do not come close to coinciding.

Now imagine not two, but four, viewpoints superimposed. The different images begin to merge to produce the familiar image of then King in focus but the other pieces out of focus to a greater or lesser extent.

Four Viewpoints Superimposed

Wide Aperture Image of the Chess Pieces

If you imagine hundreds of different, but very similar viewpoints they would merge to produce the familiar image displaying depth of field.

For a small aperture, the different viewpoints would be very similar which you would see as a large depth of field. If the aperture is greater, the viewpoints would differ more and you would see a reduced depth of field.

Depth of Field in Practice

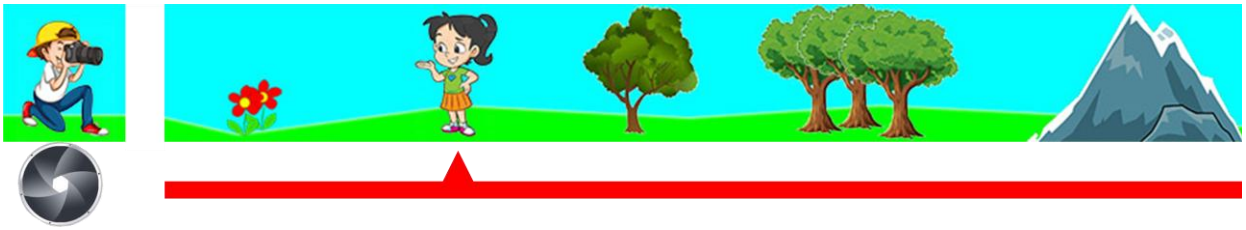
There are two things you need to consider:

- the effect of different apertures;
- the effect of different distance.

So, let's take them separately.

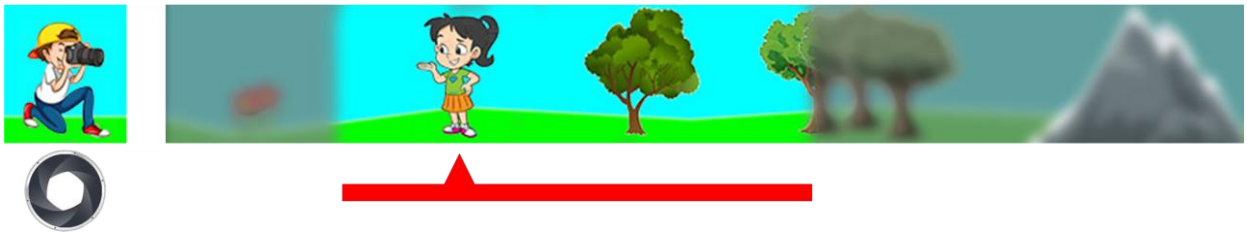
Different Apertures at the same Distance

Here we have a photographer and his girlfriend taking pictures in the countryside. Naturally all his attention is on his girlfriend and he would like the photograph to reflect that. Naturally he focuses on her. However, with a small aperture the depth of field is large. So, not only does he get his girlfriend in focus, so are the flowers in the foreground and the trees and mountains in the distance.



A Small Aperture produces a Large Depth of Field

Realising that this is not such a good idea, he stops the lens down a little. This means that the mountains and flowers are now out of focus. However, the trees in the middle distance are still a problem



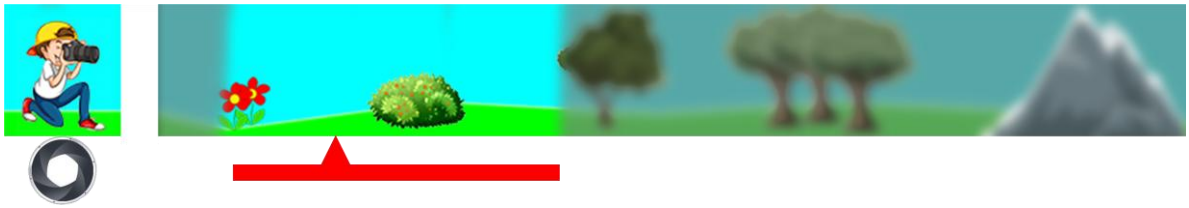
A mid-range aperture Limits the Depth pf Field

Finally, he opens up the aperture completely. Now, at last, the depth of field has been limited to his girlfriend and he manages to take a flattering photograph where all the attention is on his girl.

A Large Aperture produces a Very Limited Depth of Field

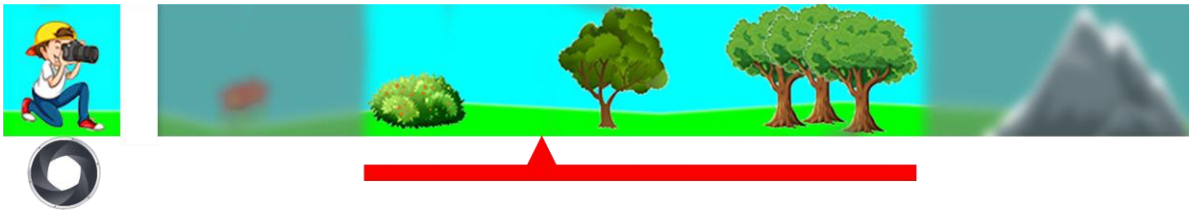
The same Aperture at Different Distances

Our favourite photographer has now split with his girl and he is reduced to capturing landscapes. Using a mid range aperture, he first focuses fairly close up. The effect here is to limit the focus to things near to him; flowers and bushes.



Focusing close produces a small Depth of Field

Focussing a little further away increases the depth of field. The flowers are now gone but the trees are in focus. The mountains, however, are still blurred.



Focusing Further Away Increases the Depth of Field

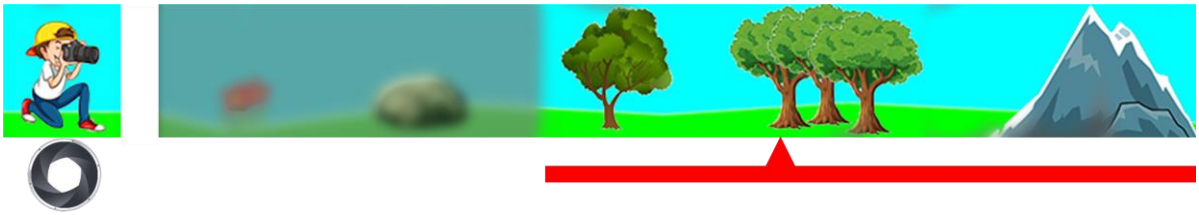
Focussing even further away, there is a distance called the "Hyperfocal Distance" at which the distant mountains are just in focus while including as much as possible of the foreground.

In the past prime lenses had a depth of field scale from which it was easy to set the hyperfocal distance. On-line you can find tables from which to read off the hyperfocal distance. Ultimately, however this does not help when you are constrained by auto-focus.

There are several rules of thumb which photographers have come up with to achieve something like the same effect:

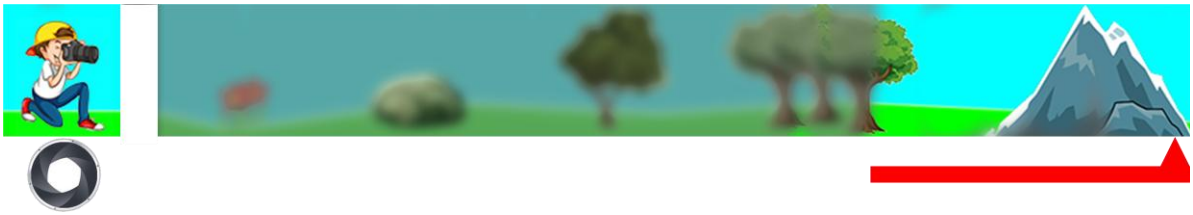
- identify something closest to you which you want just in focus and focus on something at twice this distance;
- Focus on something a third of the way into the scene (just what is a third of the distance from three feet to infinity?).

Neither of these is particularly accurate!



The Hyperfocal Distance Produces the Maximum Depth of Field

If our friend tries focussing even further away, the depth of field decreases simply because you can't include things beyond infinity in your depth of field.

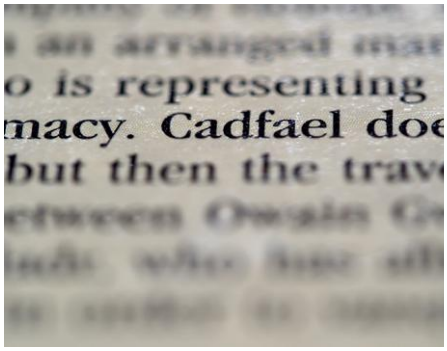


Focusing at Infinity Does not give the maximum Depth of Field

Extreme Close-Up

From what you have seen so far, the closer you focus, the less depth of field you get. In extreme close-ups, this is even more the case. Indeed, you may find that you cannot get the whole of an insect in focus at the same time.

There are techniques, such as focus stacking, to get round this. These, however, are somewhat specialist.



Extreme Close-up gives an extremely limited depth of field.

Other factors Affecting Depth of Field

While aperture is the main driver for changing the depth of field, there are other factors which you should be aware of. In particular, focal length and sensor size:

- Focal Length
  - telephoto (long focal length) gives a shallow depth of field
  - wide angle (short focal length gives a deep depth of field
- Sensor Size
  - Large sensor gives a shallow depth of field
  - small sensor gives a deep depth of field

In the middle of the twentieth century it was fashionable for studio portraits to have the eyes in focus but with so shallow a depth of field that the cheeks were out of focus. This was achieved with a medium telephoto lens and a large photographic plate: perhaps 5 inches by 4 inches. This is far larger than any sensor available today.

Summary of Depth of Field

To get a deep depth of field

- large f-stop (small aperture)
- stand away from the subject
- wide angle lens (short focal length)
- small sensor

Deep Depth of Field

To get a shallow depth of field

- small f-stop (large aperture)
- close to the subject
- telephoto lens (long focal length)
- large sensor

Shallow Depth of Field