Depth of Field Explained

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Quite possibly one of the most confusing concepts for the learning cinematographer is depth of field. The following is an attempt at explaining what depth of field is, what effects depth of field, and how it works. Please note: the 'subject' will be the point of focus for examples and explanations.

First, depth of field is simply the area of the scene that falls in focus. All conventional lenses (with the exception of specialty lenses) focus on a parallel plane to the camera. Focusing the lens moves this plane of focus closer or further to the lens. The depth of this plane, or field, depends on optical variables of the lens. In actuality, only one exact sliver of this depth can be in perfect focus across the parallel plane, yet depending on many factors there will be a varying area of acceptable focus, thus creating the size of the depth of field whether it be shallow or deep.

Shallow DoF: The area of acceptable focus around the subject is small creating the possibility that many elements in the scene may fall considerably out of focus.

Deep DoF: The area of acceptable focus around the subject is large causing the possibility that many or all elements in the scene may be in focus.

The area of acceptable focus falls unevenly around the exact sliver of perfect focus. Books, professors, or colleagues will report that 2/3rds of the acceptable focus 'zone' will fall behind the point of focus, while the other 1/3rd falls in front. This is simply a generalization. It is true, however, that the majority of the focus will fall behind the subject. The exact fraction of difference depends on your camera, focal length, selected f-stop, and subject distance. Sometimes there may only be a 20% difference between front and back acceptable focus (40% front, 60% back) while other times it may be much more or less lopsided. Check out an online depth of field calculator to confirm this.

Online calculator #1
Online calculator #2

What effects depth of field?

There are only three factors that affect depth of field, with a fourth overlaying issue I will discuss in the end.

1. *Lens aperture*. When the lens aperture is set at a lower f-stop/t-stop ('opened up'), the depth of field will decrease causing less of the scene to fall within the parameters of acceptable focus. When the lens aperture is set at a higher f-stop/t-stop ('closed down'), the depth of field will expand allowing more of the scene to fall within the acceptable focus area.

2. *Focal length*. Longer focal length lenses (telephoto) decrease the depth of acceptable focus; less depth of field. Lenses with shorter focal lengths (wide angle) increase the depth of acceptable focus; more depth of field.

3. *Lens to subject distance*. The distance from which the subject is from the camera will directly affect depth of field. A subject very close to the camera will cause the depth of field to decrease, causing more of the scene to fall out of focus. A subject placed far from the camera will inherently cause the depth of field to increase, allowing more of the scene to be in focus.

The Ying & Yang

The problem with elements 2 & 3 is that they counteract each other, if you are composing the frame for the same composition. For example if you wanted a CU of a woman where the frame lines would fall at the crown of her head and at the bottom of her chin, you could shoot it one of two ways:

1. Use a wide-angle lens (greater DoF) and move the camera closer to the subject (less DoF.)

2. Use a telephoto lens (less DoF) and move the camera further from the subject (greater DoF.)

When the focal length is doubled the camera to subject distance is doubled. When the focal length is halved, the subject to camera distance is halved.

As you see, these two elements appear to cancel each other out... but do they? Many will claim they do, but if you consult a depth of field calculator you will see there is a slight discrepancy between the two. The following example is like, but not specific to the CU example before:

1. The subject is 50' from the camera, which is equipped with a 100mm lens set at an F/4. The format is Super 35mm 1.85 projection aperture:

    - The field of view (frame) is 12' in width, and 6.5' in height.
    - The total amount of acceptable focus, Depth of Field, is 15.755' feet.

2. The subject is 25' from the camera, which is equipped with a 50mm lens set at an F/4. The camera is a Super 35mm 1.85 projection aperture.

    - The field of view (frame) is exactly the same: 12' in width and 6.5′ in height.
    - The total amount of acceptable focus, Depth of Field, is 16.9903' feet.

The subject was moved forward half of the distance, and the lens was reduced half the length to match the same composition (compare field of view numbers). From the result of this calculation, having the subject closer to camera and yielding a wider angle lens would give a slightly deeper depth of field vs. having the actor further away and using a longer lens to achieve the same composition.

Shooting Format

There are only three variables, which determine depth of field. But… there is a fourth overlaying element, which should be taken into account before applying the previous three variables. The element in question is the size of the video sensor or size of the film plane.

When deciding a shooting format, knowing the size of your sensor/film plane, is a very important factor. The rules are the same in video as they are in film. Larger format sizes are inherently shallower in depth of field. Smaller format sizes inherently have more depth of field. Remember we are not discussing resolution, but rather the size of the imaging plane. Also note, one can attain deep depth of field on a large format and shallow depth of field on a small format, although doing so will be more difficult.

The relationship between lens focal length and field of view is the explanation behind the formats inherent liking to different depth of field qualities. Since cameras with different image plane sizes, the fields of views are not the same, therefore to get the same composition/frame, different focal length lenses must be used, and that changes the depth of field. Therefore if anyone ever argues that format size does influence depth of field… it does, but not directly. It's still focal length.

Example: 35mm film vs 16mm film

Super 35mm film camera (1.78 HDTV TV Transmitted)
- A subject is 20 feet away
- Camera has 100mm lens
- Field of View
  - Height= 2' 7 1/4"
  - Width= 4' 7 1/2"
- Depth of Field= 2' 5 1/4"

Super 16mm film camera (1.78 HDTV Transmitted)
- A subject is 20 feet away
- Camera has 50mm lens to adapt to the 16mm's different field of view due to its smaller frame size.
- Field of view
  - Height- 2' 7 3/4"
  - Width- 4' 8 1/2"
- Depth of Field= 4' 11 3/4"

The result is not 100% expected, as the field of view is about one inch off. This is most likely due to 35mm being slightly larger than twice the size of 16mm. What one *can* see from the results is with almost identical compositions and f-stops, 35mm film has *half* of the depth of field 16mm has.

The same can be applied to video sensors. It is well known that 1/3" chip CCDs have inherently greater depth of field, as it's larger 1/2", 2/3", or higher chip brothers.

35mm Adapters

Because many 1/3" chip CCD users desire shallow depth of field, but have difficulty achieving adequate results, the introduction of 35mm adapters has been very successful. The adapter allows lenses to be attached to a device upon which a ground glass acts as a faux 35mm image sensor receiving the image from the taking lens. The 1/3" CCD camera lens then macro focuses to and records the ground glass 'rear projection' like image. The image plane went from 1/3" to a size about that of 35mm photography film.

Anamorphic Widescreen 2.40

Anamorphic lenses are not rated like spherical lenses. This is because the horizontal focal length is actually that of a spherical lens with half the focal length.

For example: if you have a 100mm anamorphic lens, its horizontal focal length is more like a spherical 50mm lens.

- 100mm anamorphic lens has the horizontal field of view of a 50mm spherical lens.

- 100mm anamorphic lens has the vertical field of view of about a 100mm spherical lens.

Additionally, anamorphic lenses are known to possess a slight arc in the focal plane. As mentioned earlier, a lens can only be precisely focused onto one parallel plane in a scene. Focusing brings this exact plane closer towards or further away from the lens. In anamorphic lenses the plane of focus is slightly bent.

Example:

- Regular Spherical lens photographs a row of soldiers standing in perfect alignment in front of the camera lens. The soldier line is exactly 20ft in front of the lens. If the lens were focused to 20ft, anything on that focus plane is in focus. From the first man on the left to the last on the right.

- Anamorphic lens photographs the same row of soldiers, all standing in a perfect row 20ft from the camera lens. The anamorphic lens plane of focus is NOT perfectly parallel. Focused at 20ft, the soldiers on the flanks of the line will be softer than the men in the middle. When shooting anamorphic, many cinematographers will shoot with a greater f-stop, allowing the expanded depth of field to hide the bend focus plane. Other cinematographers will block actors or action to take place in a slight arc, as to stay in the bent focus plane.

That concludes the depth of field explanation. Comments, suggestions, or questions are always welcomed. Images and diagrams should appear in the distant future.

Best,

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