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Intro to Imaging and Video Systems

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1. 1. https://s3.amazonaws.com/red_3/uploads/asset_image/image/4fce74c717ef024394001c6b/exposure-timeline-270.pnghttps://s3.amazonaws.com/red_3/uploads/asset_image/image/4fce565d2f74a95d60001985/exposure-timeline-180.pngShutter angles control the amount of light that is exposed per frame, but also describes the exposure duration. A larger shutter angle allows for more light exposure, but also means there is a longer exposure duration because the frame is exposed in the field for a longer period of time. Controlling the shutter angle helps control the motion blur in the video, where a large shutter angle will allow motion blur and a small shutter angle inhibits it [1]. The figure above describes the motion of two shutter angles, at 180 and 270 degrees, where the area in red is when the shutter is open and light is exposed.

270 degree shutter

180 degree shutter

The mathematical equation relating shutter angle and exposure time is

*Shutter angle/360 = exposure time\*framerate.* [2]

The equation can be written multiple ways, some involving frame interval instead of frame rate, but the relationship between shutter angle and exposure time remains the same. By looking at this equation, shutter angle and exposure time both have a direct relationship and that makes sense because a larger shutter angle will mean there is a larger opening for light to enter, meaning light is present in the frame for a longer period of time, hence a longer exposure time. But the exposure time is written as a fraction, so the value in the denominator will be smaller for a longer time than a shorter time (A value of 1/50 is larger than 1/100). This applies to the frame rate as well. If the exposure time is longer, its denominator value is smaller and by completing simple algebra, a smaller value in the denominator will yield a smaller framerate and a larger value will yield a larger framerate.

* 1. One simple and obvious way to manipulate exposure is to control the amount of light present in the object’s setting. Controlling the amount of light on the object side, before it enters the camera, is a simple way to control exposure without altering the frame rate. In brightly lit rooms, dimming the lights or using fewer ones can help control exposure. Adding neutral density filters can work for this as well by limiting the overall intensity of light at all wavelengths so there is no rendition of a certain hue over another [3].

The ISO setting within the camera is another way to manipulate exposure. ISO represents the camera’s sensitivity to light in the frame and essentially determines the overall appearance of a still image or frame [3]. If the ISO is increased, the camera is more sensitive to light and the sensor is able to capture images in low-light environments, which manipulates the overall exposure.

Aperture is another setting on the camera that can manipulate light exposure. Rather than controlling the amount of light in the physical setting, controlling the aperture restricts the amount of light that actually enters the camera, so any control of the light prior isn’t necessary. A larger aperture represents a larger opening in the diaphragm that, when the shutter opens, allows more light to enter the camera. A smaller aperture blocks more light than it allows in which decreases the exposure, without influencing the frame rate of the camera.

If there aren’t any variations done before taking images or videos, post processing techniques such as those in Photoshop can also help control exposure. There are multiple techniques to change the overall brightness of the image as well as the tonal values. There are some disadvantages because highlights in the image prior to editing can get clipped and make the area appear much brighter than it should be. On the other hand, any dark areas can get crushed even more if the overall brightness of the image is decreased.

* 1. As stated earlier, one main reason behind controlling shutter angles to control the motion blur in an image, which is an artifact that involves streaking caused by moving objects in a still image. Fast movement along with a longer exposure duration can cause this to occur and in still images. In film, motion blur further emphasizes the illusion of pure motion, but an excessive amount can be unflattering [2]. For example, when watching televised sports, a lot of motion blur prevents someone from seeing the exact positions of an athlete in motion, and causes headaches. That is why a 180 degree shutter yields optimal results – the angle is wide enough to allow motion blur to occur but isn’t too wide that the blur appears unnatural. It prevents the motion blur of two succeeding frames from overlapping.

Another artifact is overexposure, coming from a larger shutter angle yielding a longer exposure time. Too much exposure can make a still image or frame much brighter than it should be. So in a brightly lit room or in bright daylight, decreasing the shutter angle can help restrict the amount of light to enter the camera lens and expose the image or frame, which can help it appear sharper and have better exposure.

1. The introduction of 29.97 frames per second came with the introduction of color television. On black and white televisions, the framerate was 30fps because it was half the oscillation of AC electricity, 60Hz, and the horizontal pixel value was labeled as 480, yet the actual value was 525 to follow with the transitions of the interlace pattern [4]. Black and white televisions utilized a “raster” pattern to scan images and frames and display them across an image and when color was introduced, an extra color subcarrier was meant to go through the signal as well, but it was phasing with the sound carrier signal because they were so close in the spectrum, making the image very difficult to watch [5]. The color subcarrier frequencies were meant to be multiples of the line frequency, which is why a framerate of 30 frames per second fit well with the 480 line television (480/30 = 16).

To fix this, engineers shifted the frequency used for the color carrier by a small amount to have a slight reduction in the line frequency. The line frequency corresponds with the frame frequency, so the reduction also led to a slightly lower frame rate – by .03 frames per second – yielding a final frame rate of 29.97 frames per second [6]. Since the broadcast pattern of that time was interlace, the framerate of 30 frames per second yielded a total of 60 fields per second, so the 29.97 frames per second reduced that value by .06 – two times the frame difference of .03 – making the framerate yield a total of 59.94 fields per second. So there is a slight shift in the number of fields present from the frames, but it goes unnoticed when actually watching a video on the display screen.

A New Way to Think About High Definition

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High definition is everywhere nowadays and is the backbone of all new technology. Besides just television, online video streaming formats like Netflix and Amazon Prime Video have begun utilizing the HD format, along with video games and video game consoles like Xbox and Play Station. HD has been around for a while, around a decade, though there are still confusions about the different formats of HDTV and how they vary from one another. There are so many numbers, letters and abbreviations that fly over the consumer’s head, but now I’s time to understand HDTV.

First thing is that there are multiple display formats of HD, but the two most common are 720p and 1080i. What does “720p” and “1080i” even stand for? The abbreviation isn’t really complicated. 720p essentially represents 720 rows of pixels across the screen that are *progressively* broadcasted (hence the “p” for progressive). This means each frame is sent in as a whole every 60th of a second, or twice every 30th of a second, to the display screen. 1080i represents 1,080 rows of pixels that are broadcasted using an *interlaced* signal (“i” for interlace), so odd lines of pixels are sent to the television, followed by even lines. This creates an alternating pattern where each set of lines is shown every 30th of a second, and each frame switches every 60th of a second. Naturally, it would be assumed that since there are more rows of pixels in 1080i than 720p that there would be better resolution, but since only half the detail is presented every 30th of a second due to the interlace pattern for 1080i, artifacts such as jagged edges start to appear when broadcasted, reducing the resolution, and nobody wants that. So 1080i, despite more pixels, has almost the same resolution and quality as 720p.

But despite this potential consequence, some television stations still utilize the display format, including some of the most popular and famous channels like CBS, NBC, CW and more. Channels like ABC, Fox, and ESPN utilize the 720p display format. There are more channels broadcasting with 1080i than 720p, which seems confusing because the interlace pattern on 1080i means there’s more compression that will need to occur to broadcast the signals through a television that encompasses progressive scanning. But at the same time, the artifacts leave unnoticed by the human eye because they’re very small and the average human won’t be sitting exactly 1 foot away from the television screen. In fact, we probably won’t change our distance from the TV – we may just change the TV itself and because of that, we don’t catch the little issues that occur with the compression and bandwidth, and since 1080i encloses more overall pixels, it does produce more detailed images and frames. So, despite the variation in numbers and letters, these two display formats are almost the same, and yet the beauty of business lures consumers into thinking they’re different!

Now, 720p and 1080i aren’t the only two display formats for HD. Along with the interlace pattern of 1080i, 1080p also involves 1080 rows of pixels and this time, it portrays the frames progressively, the same as 720p. 1080p is sometimes dubbed as the “true” or “full” HD mostly to distinguish it from 1080i and 720p. It’s also said to have a much better resolution than 720p with its progressive scan. So why isn’t this display format being utilized more often or as much as its opponents? 1080p contains more pixels and uses the same scanning method so it should be a better choice for HDTV. The only problem is that most broadcast stations still use either 720p or 1080i display formats, which means the compression methods to fit the resolution would increase bandwidth and force cable providers to develop new equipment. Although the screen is “High Definition”, it appears the same as all other HD televisions on the market because of this compression and bandwidth issue. In fact, Blu-Ray is the only current format to display pure 1080p content. Some cable providers offer 1080p content in Pay Per View, but besides that, displaying content in the 1080p format is very unusual and very complicated. That’s why broadcasters and cable providers steer away from it.

When all of these formats of HDTVs were first released, everyone went crazy buying new televisions, and now, each year, there are more and more televisions hitting the market to lure consumers into more and “better” televisions. It’s an entire ecosystem: the algorithms, pixel resolution and compression mechanisms keep improving and this time, the hype isn’t “HD”. It’s *Ultra* HD. Ultra-High Definition is the next stage of television, where the resolution is a whopping 4096 x 2160 pixels, hence the term “4K” for the horizontal pixel value. It’s a noticeable upgrade with 4x as many pixels, so broadcasters and cable providers are quickly getting into the action. DirecTV became the first television provider to offer 4K content, but it was limited to on-demand films. The British sports channel BT launched its own 4K channel. Even Netflix joined in and began offering 4K streaming on some of its original content. There haven’t been any networks on television who have begun offering UHD/4K content yet, but BBC is set to start sometime this year. Also, there are still some televisions on the market that still incorporate 720p formats, which is why we haven’t averted from it just yet and turned completely to UHD.

Ultra HD is just beginning to take shape which is why there haven’t been many broadcasters to associate with it. Soon though, UHD will become a thing of the past and soon enough, a newer and “better” television format will come along.

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