Virtual Reality Engineering
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Lecture – 42
Gamma Encoding

We all have cell phones, and we take images with cell phone, photographs with cell phone. Have you observed that our cell phone photographs are different from what our eyes look at? The way we see as scene is different from what the cell phones records. Have you observed it many times? The same image when you send it to your friends, that image may be looking different than what your cell phone has recorded, have you observed this?

Let us look at why this is happening using some of the psychophysical concepts we have learnt in the previous classes. Let us start looking at how yeah camera records an image.

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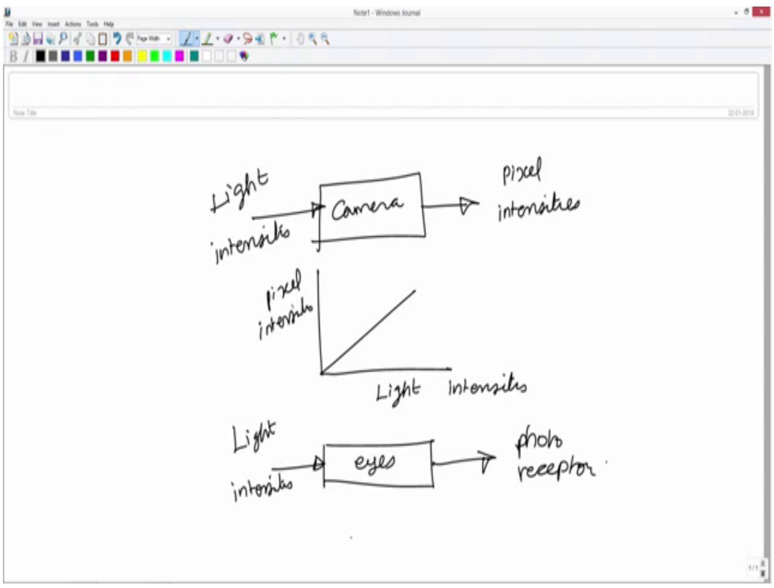

We have a camera, the input to the camera is a light intensity, the camera records the image into pixel intensities. But what is a relation between this light intensity to the pixel intens intensity? This could be a is it a linear relation or non-linear relation, what could be the relation? Let us plot that into light intensity and a pixel intensity in the y axis, then what we would get is a linear relation between the light intensity and the pixel intensity.

The same thing if you look at our eyes, the same light intensity if you input what our photoreceptors see non-linear such as this in the eyes.

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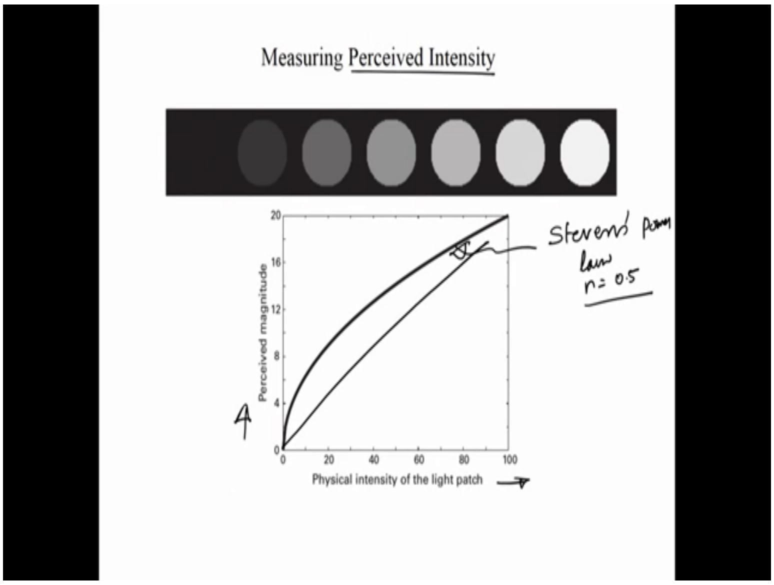

This is one of the reasons why our photographs, our cell phone cameras, record a different image then what our eyes see, what we actually see.

Now, how do we solve this problem? First of all, why eyes have this non-linear relation, why not it have same relation as the camera.

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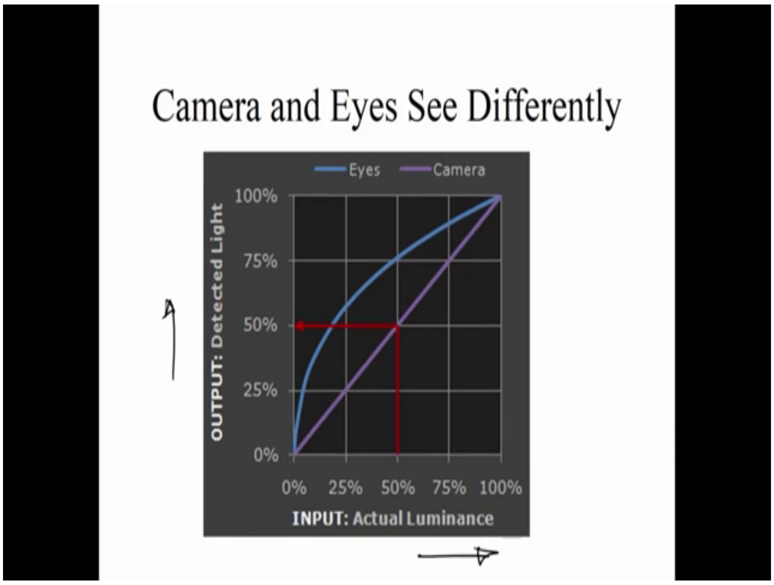

So, the same graph what I have shown in the earlier plot is slightly put it in different format over here, in the x axis is the actual luminance, the y axis is detected light, and the blue line is for the eyes and the purple line is for the camera.

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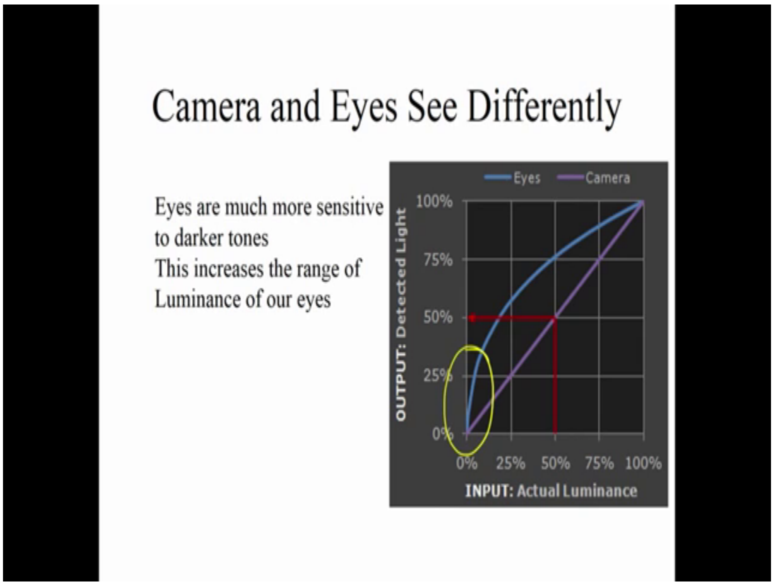

The eyes are much more sensitive to darker tones. Because of the non-linear relation, if you look at the darker tones, the eyes are much more sensitive to the the darker tones compared to the the camera ok. So, that is the implication of having a non-linear relation, the power relation which is less than and 0.5.

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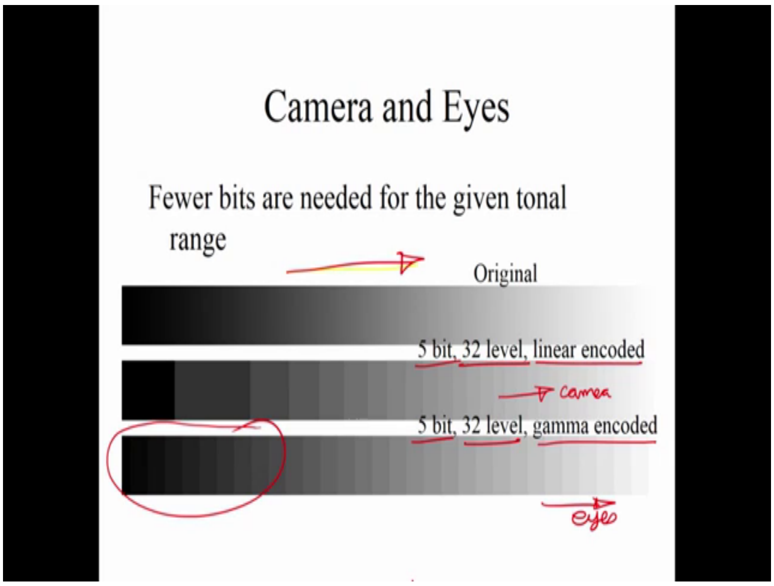

So, what so, because the eyes are sensitive for the darker tones, if you look at the original image, this is a natural seen let us say, where the dark to light is continuously changing, if you linearly interpolate the intensity, let us say and then we will digitize it. Let us say it is a 32 level we wanted to divide the whole intensity variation, and using your 5-bit encoding, then what we would get is like this. It is almost like what our camera see, this is what the camera is actually seeing it, right.

The same thing with a non-linearly if you encode it, this is what our eye see. You can observe that in the darker region, you can see many variations. So, we are just for demonstration, we are using the same 5-bit 32 level division of the entire intensity variation. For this variation, you can see that the darker region has much final encoding, much final now variation we could observe it, that is because for the non-linear relation. This encoding is termed as gamma encoding.

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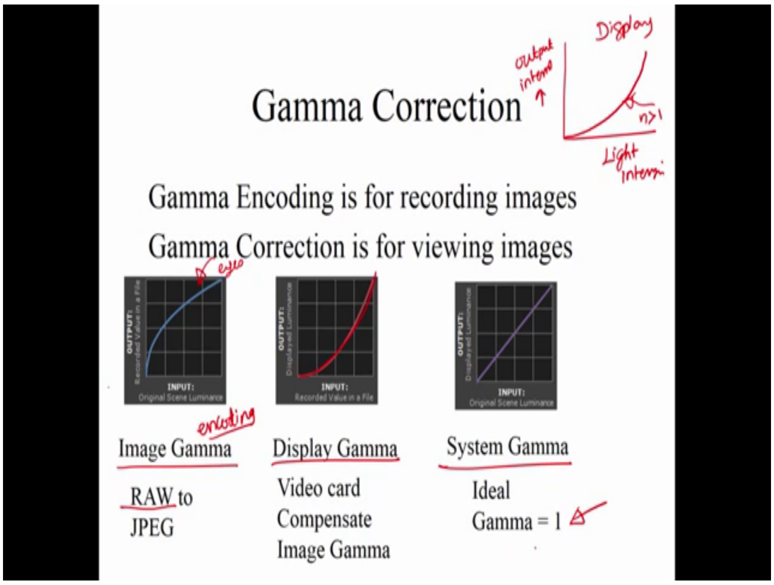

So, if you have an image, which is recorded by a camera, which has a linear relation. In order to make it yeah image make it similar to what eyes have seen, then we can change the the linear relation into a non-linear relation. That is called the image camera. The raw image which is recorded using your linear, we can add power relation as of in our eyes, and then make it to very similar to what our eyes have recorded, then and that is called the image gamma, or gamma image gamma encoding.

You are encoding the gamma into the image, then that image looks much more closer to what your eyes have looked at ok. Now, this is what the image gamma is, when you display the image in a screen, the each of the displays has it is own gamma, but this gamma is actually in the inverse. So, again if you look at the light intensity in the x axis, and output intensity, intensity in the y axis, then the displace have the non-linear relation, but it in the y this is in the power relation with a n greater than 1.

So, this is inherent in some of the displace, in some displays it is 2, in some displays 3, and some displays it is one point one or whatever. So, this is called the display gamma. So, you can change that display gamma you can actually modify it. So, the image gamma under display gamma together when update together is called the system gamma; together the final image will have this 1.

Ideally every display should have a gamma 1. If every display has ideal gamma 1, then we do not need to encode the images with gamma. It can directly we can display on the screen, but that is not the case in real conditions.

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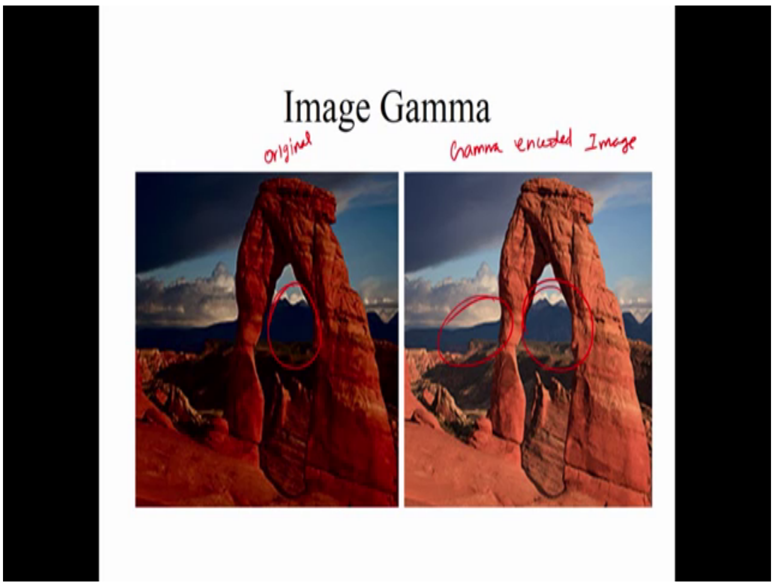

This is one of the examples of the image gamma encoding. This is a original image, now after encoding the gamma, gamma encoded image. You can see the difference between the original and the gamma encoded image; in the original image if you look at the place where the darker regions are there the details are not very well visible. Whereas, in the gamma encoded image, you can see the darker regions of the image the details are very well visible.

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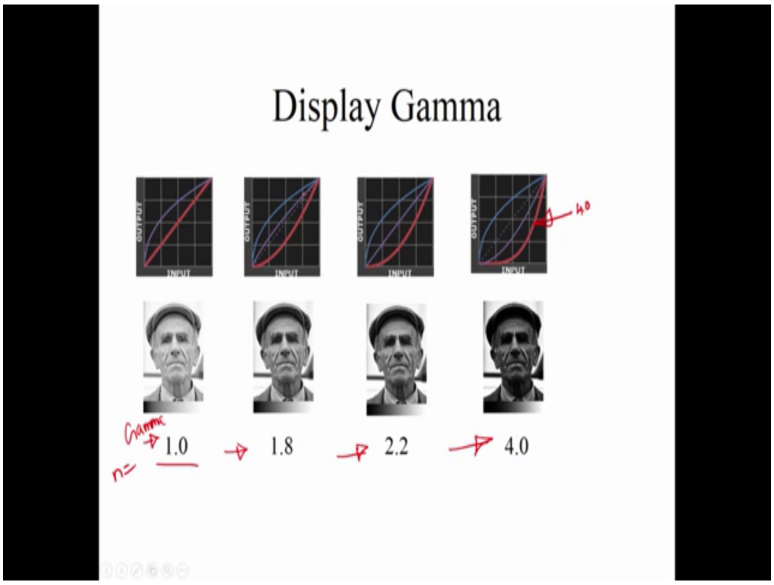

So, the display gamma, let us see how it influences the image. Let us take one original image, with when it is displayed on the screen with a gamma 1, you can see that that is the same as the image; when you increase this gamma to 1.8; you can see that the compensation the image encoded gamma encoded image is getting compensated.

You can see that you would be looking at the now closer to the original image, when it has increased further you can observe that there are more darker regions are coming up, and this is the the very high highly docked on darker version of the image is coming up, if this is too much of bending when n is equal to 4, this is the gamma n is equal to 4 or gamma, this is 4.0, where you can see that the image is getting darken.

So, ideally the image gamma under display gamma should match, and the resultant system gamma 1.

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Most of the monitors have their inherent gamma in it. There are CRT monitors with a native gamma of 2.5. The current is probably none of us use these CRT monitors. But you can you can still there are some places where CRT monitors are user. You should know that that gamma is very, very high. So, without a gamma correction, the image will be very different.

So, when you send an image to your friend, that friend may not see the same image as in your display, because your display gamma is different from your display your friends display gamma unless you match. The same display gamma you and your friends may not see the same image. There are the LCD monitors with a native gamma of 1.2.

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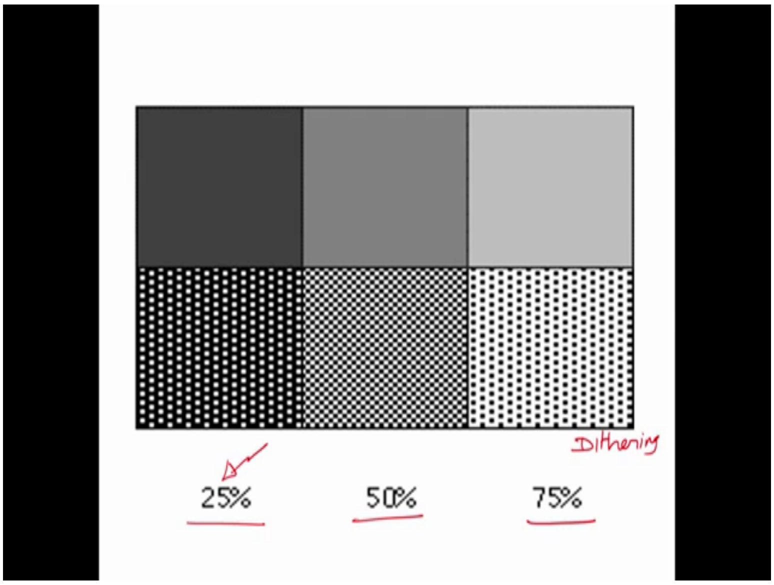

Now, how do we know how much is a gamma my display is? There is a very simple system or procedure researchers have come up with. So, you are you can see an image in the screen, where the top row has 3 gray levels, one is a darker medium and the lighter one. The bottom row has dithered black and white regions, which is mimicking these gray level images in that top row.

So, which row ok, we can say that this is a 25 percent of the dithering in the bottom row, that is the mixing of black and white dots. Here it is a 50 percent mixing of black and white dots, here it is a 75 percent mixing of black and white dots. Here the black region is more, and then white region is less, 25 percent of the white regions, and 75 percent of the dark region. Here the inverse, 25 percent of the black regions and 75 percent of the white region.

Now to find out the display gamma, what which column looks approximately same in your display. So, in our case, this first row, where the darker gray and the 25 percent of the dithering, this is called a dithering let me write it on, looks similar. Therefore, our gamma of the monitor may be may be at this level.

So, matching the top row and the bottom row, whichever we perceive similar, that is what leading to the concept of the gamma. That may be the the display gamma, which is such in your display. In order to make it a little more now final the same thing has many different levels of gray and dithering.

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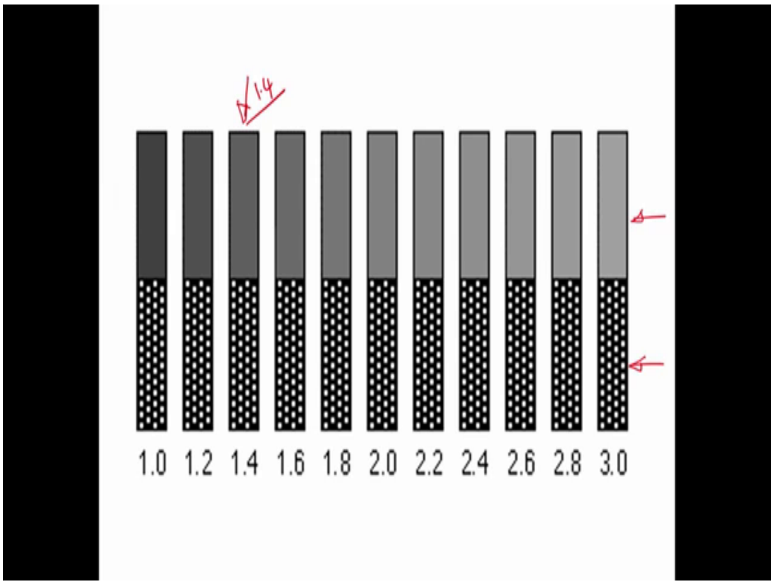

So, which top, which column has the same at least appearing to have the same top and bottom levels. Say for example, in our system it appears to be it appears to be around this 1.4 or 1.6. This may be set as the gamma in our display. Now you can pass a minute of this video and then find out what is your display gamma using this image. So, the concept of gamma is very important to have a the same image as what your cameras have recorded. In the virtual reality systems, you may be using many images and textures, and then textures should have the the should appear the same way what you have actually your eyes look at it.

For this to happen you have to either encode the images or or or and you may have to adjust the display gamma appropriately. The oculars and the why displace is have to have a corresponding display gammas. You need to find out first of all all what is a gamma this VR systems uses, and probably you may have to correct the images according to the display gamma or the vice versa.

Thank you.