Assignment 2

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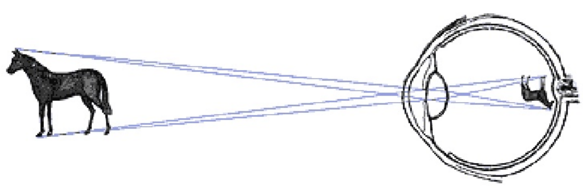
1. *Image Formation*

   When light falls on an object it gets reflected back. This reflected light can be perceived by the human eye. The light bouncing back from an object goes through the human eye lens and gets projected onto human retina. Human brain can interpret this image formed on the retina and we are able to understand what we are seeing. A notion of depth and height is also established due to the different angles the image can be formed on the retina while looking at it from different positions and angles.

Formation of image on retina

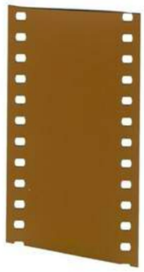


http://www.bausch.com/us/vision/teens/illusions/eyeworks.jsp

   In our physical world we have a concept of signal. Any physical quantity can be measured over time and other dimensions. A signal is a mathematical function which can represent some information. Our idea should be to capture this signal. Signal in our case is the image which can be obtained from the intensity of light being reflected from it.

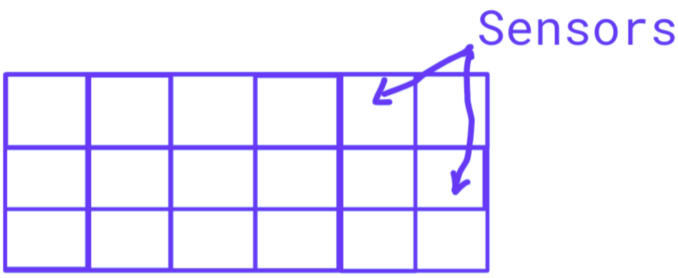
Source: tutorialspoint

   A sensor can be used to sense the amount of light reflected from a surface or object. Now this sensor can generate a continuous electric voltage proportional to the intensity of light received from an object. We can sample and process this voltage and use appropriate representation to store the image generated in computer system.



Source: tutorialspoint

In analog cameras, the image formation is due to the chemical reaction that takes place on the strip that is used for image formation. Light is nothing but just the small particles known as photon particles. So when these photon particles are passed through the camera, it reacts with the silver halide particles on the strip and it results in the silver which is the negative of the image.



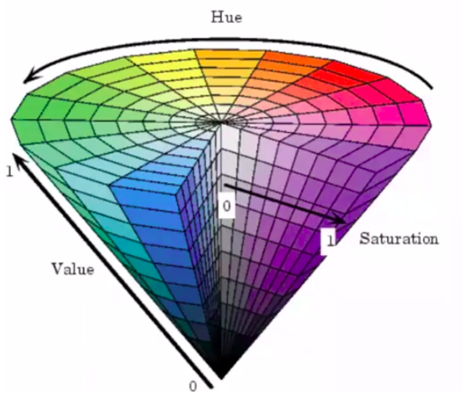
In digital cameras there is no chemical reaction as such but it happens little differently. An array of CCD sensors is used for image formation. The sensor senses the signal values and converts them into electrical signal. Each sensor of the CCD array itself is an analog sensor. When photons of light strike on the chip, it is held as a small electrical charge in each photo sensor. The response of each sensor is directly equal to the amount of light or (photon) energy that strikes on the surface of the sensor.

The value of each sensor of the CCD array refers to each the value of the individual pixel. The number of sensors = number of pixels. It also means that each sensor could have only one and only one value. The charges stored by the CCD array are converted to voltage one pixel at a time. With the help of additional circuits , this voltage is converted into a digital information and then it is stored.

Image quality is influenced by the quality and type of CCD sensors used.

2. *Image Representation*

(a) HSV model



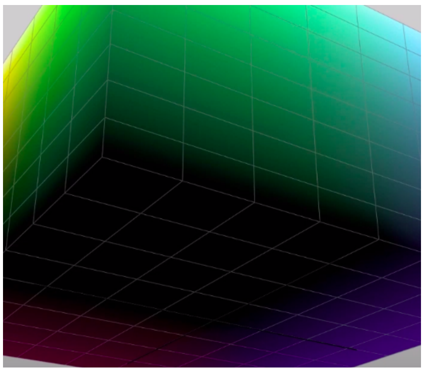
Unlike RGB which uses primary colors to represent the image, this model uses a representation which is more closer to how human eye perceives colors. It has 3 components: Hue, Saturation and Value. This color space describes colors (hue or tint) in terms of their shade (saturation or amount of gray) and their brightness value.

Hue is the color portion represented as a number from 0 to 360 degrees.

Saturation describes the amount of gray in a particular color, from 0 to 100 percent. Reducing this component toward zero introduces more gray and produces a faded effect.

Value is the intensity of the color, from 0 to 100 percent, where 0 is completely black, and 100 is the brightest.

(b) L* A* B* Model



L*a*b* color space was modeled after a color-opponent theory stating that two colors cannot be red and green at the same time or yellow and blue at the same time. L* indicates lightness, a* is the red/green coordinate, and b* is the yellow/blue coordinate. We have separated the color out into A and B channel and luminosity into L channel. In A channel we can think of it as positive and negative numbers. Positive will be warm colors and negative will be cool colors. Similarly for B channel.

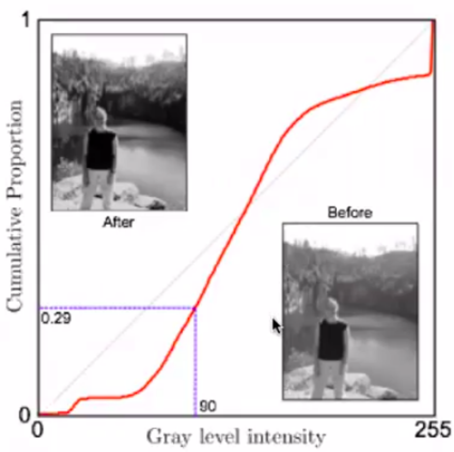
3. *Image Enhancement*

Let us consider a gray scale image. All the pxels in the image are represent using a value from 0 to 255. There could be 2 potential problems with a particular image. Either the image is not centred at the 127 or it is not occupying the full spectrum of values from 0 to 255. Either of these will make the image look bad. If it is centred at let's say 20 then it is closer to 0 and will appear black. If it centred at 200 then it is closer to 255 and will be appear white. These are the basic issue which image enhancement tries to address.

(a) Whitening

Compute the mean and standard deviation using all the pixels. Then for each pixel we can subtract the mean and divide by standard deviation. So we are doing centering and taking care of scaling.

(b) Histogram Equalization



We construct a histogram of an image using the pixel intensities. For each pixel value we accumulate how many times it occurs and plot a histogram. Next we calculate the cumulative histogram and normalize it. Once we plot the cumulative values vs intensity values, we can use the plotted line to map the pixel intensity to a cumulative value. Let's call this value as a. We just have to multiply a with 255 and get the equalized value. It effectively spreads out the most frequent intensity values, i.e. stretching out the intensity range of the image. This method usually increases the global contrast of images when its usable data is represented by close contrast values. This allows for areas of lower local contrast to gain a higher contrast.