

## Histogram

The histogram of an image is the plot of the number of pixels of each gray value against the number of gray values used to represent the image. If an image has total  $L$  gray values ranging from  $[0, L - 1]$ , then the histogram has  $L$  elements, each element  $i$ , is the number of pixels having gray value  $i$  in the image. The sum of all the elements of histogram  $H$  is equal to the total number of pixels in image, which is same as the image dimensions. Usually, the histogram is divided by the image dimensions to convert it into the normalized histogram. In this case, the sum of elements equals 1. Histogram is one of the important representations, and it is helpful in several applications such as image manipulation, digital photography, image quality analysis, etc. If the histogram of an image has higher values in the left side, the image tends to be darker. In this case, there is a possibility that there was insufficient illumination while the image was taken or that the image was under-exposed. On the other hand, if the histogram has higher values towards its right side (which represents values close to the highest gray value  $L - 1$ ), then the image appears bright. This might also indicate that the image has been overexposed and therefore the intensity values got saturated. The images with a wider and uniform histogram generally have good contrast, and they are visually appealing. A normalized histogram is calculated as follows:

$$H(i) = \sum_{i=0}^{L-1} \frac{n_i}{MN}$$

where  $n_i$  is the number of pixels having gray value of  $i$  and  $M, N$  are the number of rows and columns of the image. The normalized histogram can be treated as a probability distribution function (PDF) of the image to analyze some of the higher statistical quantities related to the image.