ENPM673: PERCEPTION FOR AUTONOMOUS ROBOTS

Project 2

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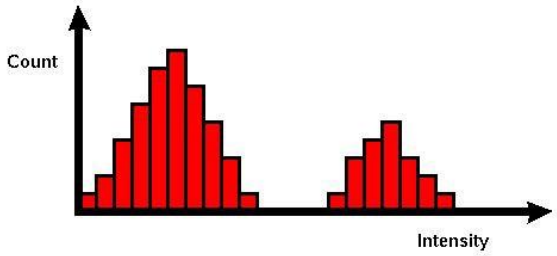
PROBLEM 1.1: Histogram Equalization & Adaptive Histogram Equalization

ANSWER:

Brief overview before getting into the problem

What is Histogram Equalization?

Histogram Equalization is an image processing technique that adjusts the contrast of an image by using its histogram. To enhance the image's contrast, it spreads out the most frequent pixel intensity values or stretches out the intensity range of the image. By accomplishing this, histogram equalization allows the image's areas with lower contrast to gain a higher contrast. Image histograms are largely used to obtain information about image attributes. The Image contrasts can be determined by looking at the range of pixel intensity values that the histogram bars are spread over.



Histogram equalization is done by using the following formula:

$$s_k = T(r_k) = \sum_{j=0}^{k} p_{in}(r_j) = \frac{(L-1)}{MN} \sum_{j=0}^{k} n_j$$

where

$$k = 0,1,2,\ldots,L-1$$

Where:

- L is the the maximum intensity level of the image. For a 8-bit image, L is 256.
- M: The width of the image.
- N: The height of the image.
- n: The frequency corresponding to each intensity level.
- rj: The range of values from 0 to L-1.
- pin: The total frequency that corresponds to a specific value of rj.
- rk: The new frequencies.
- sk: The new equalized histogram

What is Adaptive Histogram Equalization?

Unlike ordinary histogram equalization, adaptive histogram equalization utilizes the adaptive method to compute several histograms, each corresponding to a distinct section of the image. Using these histograms, this technique spread the pixel intensity values of the image to improve the contrast. Thus, adaptive histogram equalization is better than the ordinary histogram equalization if you want to improve the local contrast and enhance the edges in specific regions of the image.

Steps followed to tackle the problem:

- Read the image from the dataset provided
- Convert each image in dataset to HSV color space from BGR
- After converting to HSV, single out the value channel on which we will perform the equalization.
- We start out by storing the frequencies of each pixel intensity of the value channel in a list
- We find the cumulative sum of all the pixel frequencies.
- Then we normalize the cumulative distribution
- We get the necessary data to perform both histogram and adaptive histogram equalization.
- The cdf list is then mapped through multiplication with L-1, and stored.
- The new frequencies for each pixel are stored and by summing the individual frequencies where the values in the cdf list are equal to the respective pixel intensity.
- The equalized histogram will have bars spread out over a larger range of intensity values.
- We we merge the hue, saturation and the equalized value channels together.
- After this, we revert the color space back to BGR from HSV to display the final output

Output (Comparison between the Histogram Equalization and Adaptive Histogram Equalization):

Original Image

Frame in HSV Space

Value channel singled out

After Histogram Equalization

After Adaptive Histogram Equalization