15EEE337 Digital Image Processing

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Last lecture

- Histogram
- Histogram equalization

agenda

- Histogram matching
- Color histograms
- Enhancements using arithmetic and logic operations

Recap on how Histogram Equalization works

- **Obtain the histogram.**

$h(i) = p_i$

= (number of pixels of intensity level i / total number of pixels)

= normalized histogram = probability density function PDF

- **Obtain the cumulative distribution function CDF**

$$CDF = H(j) = \sum_{i=0}^{j} h(i) \qquad where\ j = 0, 1, \ldots\ldots, 254, 255$$

- **Calculate the transformation T to map the old intensity values to new intensity values.**

$T(j) = \text{floor}((K-1) * CDF_j)$

- **Given the new mappings of intensity values, we can use a lookup table to transform each pixel in the input image to a new intensity.**

Histogram Matching/Specification

- histogram equalization is to produce an output image that has a flattened histogram
- goal of histogram matching is to take an input image and generate an output image that is based upon the shape of a specific (or reference) histogram.
- histogram equalization as a special case of histogram matching in which we want to force an image to have a uniform histogram
- suppose we have two images, an input image and a specified image. We want to use histogram matching to force the input image to have a histogram that is the shape of the histogram of the specified image.

Steps

- **Obtain the histogram for both the input image and the specified image**

$h_{input}(i) = p_i$

= (number of pixels of intensity level i / total number of pixels)

= normalized histogram

= probability density function PDF

$h_{specified}(i) = p_i$

= (number of pixels of intensity level i / total number of pixels)

= normalized histogram

= probability density function PDF

- **Obtain the cumulative distribution function CDF for both the input image and the specified image**

$$CDF = H(j) = \sum_{i=0}^{j} h(i) \qquad where\ j = 0, 1, \ldots\ldots, 254, 255$$

- **Calculate the transformation T to map the old intensity values to new intensity values for both the input image and specified image**

$$T_{input}(j) = \text{floor}((K-1) * CDF_j)$$

$$T_{specified}(j) = \text{floor}((K-1) * CDF_j)$$

- **Use the transformed intensity values for both the input image and specified image to map the intensity values of the input image to new values**

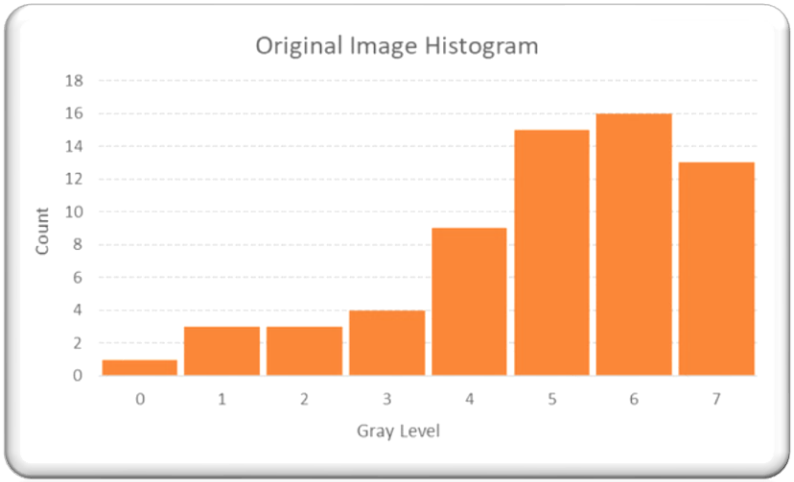
$T_{input}(4) = 3$

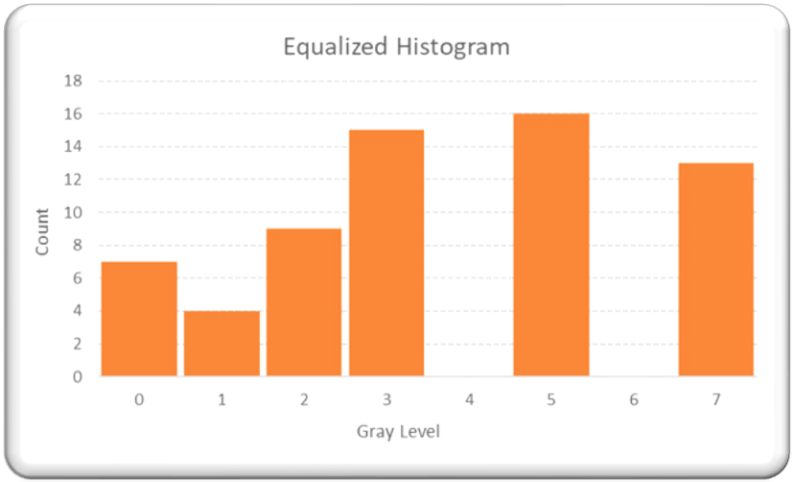
$T_{specified}(1) = 3$

$T_{input}(5) = 4$

$T_{specified}(2) = 4$

all available intensity values and performed all the mappings, we have our output image which has a histogram that will approximately match the shape of the unequalized specified histogram





Gray Level (K = 8 total levels)	Count	Probability Density Function (Count/Total Count)	Cumulative Distribution Function CDF	(K - 1) * CDF	FLOOR((K - 1) * CDF)
0	1	0.0156	0.0156	0.109	0
1	3	0.0469	0.0625	0.438	0
2	3	0.0469	0.1094	0.766	0
3	4	0.0625	0.1719	1.203	1
4	9	0.1406	0.3125	2.188	2
5	15	0.2344	0.5469	3.828	3
6	16	0.2500	0.7969	5.578	5
7	13	0.2031	1.0000	7.000	7
	64	1.000			

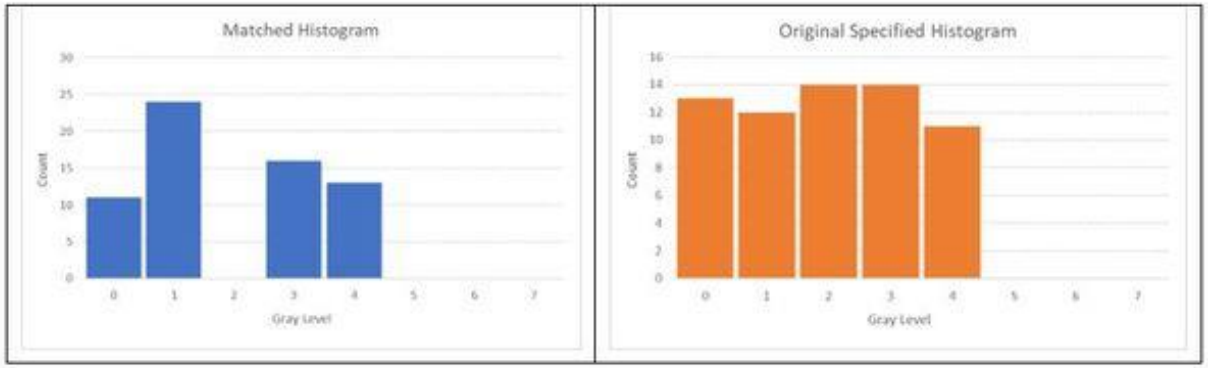
Gray Level (K = 8 total levels)	Count	Probability Density Function (Count/Total Count)	Cumulative Distribution Function CDF	(K - 1) * CDF	FLOOR((K - 1) * CDF)
0	13	0.2031	0.2031	1.422	1
1	12	0.1875	0.3906	2.734	2
2	14	0.2188	0.6094	4.266	4
3	14	0.2188	0.8281	5.797	5
4	11	0.1719	1.0000	7.000	7
5	0	0.0000	1.0000	7.000	7
6	0	0.0000	1.0000	7.000	7
7	0	0.0000	1.0000	7.000	7
	64	**1.000**			

- use the transformed intensity values for both the input image and specified image to map the intensity values of the input image to new values

Gray Level (K = 8 total levels)	Original: FLOOR((K - 1) * CDF)	Specified: FLOOR((K - 1) * CDF)
0	0	1
1	0	2
2	0	4
3	1	5
4	2	7
5	3	7
6	5	7
7	7	7

Final mapping

Gray Level (K = 8 total levels)	Original: FLOOR((K - 1) * CDF)	Specified: FLOOR((K - 1) * CDF)	Map
0	0	1	0
1	0	2	0
2	0	4	0
3	1	5	0
4	2	7	1
5	3	7	1
6	5	7	3
7	7	7	4


Matched Histogram
Count
Gray Level
Original Specified Histogram
Count
Gray Level


Original Image Histogram
Count
Gray Level


THANK
YOU