UIT2521 – Information Theory and Applications

UNIT IV INFORMATION THEORETIC IMAGE PROCESSING

Tutorial – I

Image Representation- Histogram

Date & Time: 05.11.2024 (Tuesday, 1st & 2nd Hours)

1. Can two different images have same histograms? Justify your answer.

2. Is it possible for an image to possess multiple histograms? Provide a justification for your answer.

3. Gray scale images are represented by integers ranging from 0 to 255, where 0 is used to represent utter black and 255 is used for white. What is the minimum and maximum expectation values of such images?

4. Consider two binary images represented by the following arrays:
   - **Image 1**: im1 = [0, 1, 1, 0, 0]
   - **Image 2**: im2 = [1, 0, 0, 1, 0]

   Prove that both images have the same histogram. Calculate the histograms for each image and demonstrate that they exhibit identical pixel intensity distributions. Discuss the significance of this result in the context of image analysis.

5. Suppose you have a small grayscale image with 8 pixels. The pixel intensity values are as follows:

   100, 100, 150, 150, 150, 200, 200, 255

   i. Construct the histogram of the pixel intensity values.
   ii. Calculate the PDF of the pixel intensity values.
   iii. Explain the relationship between the histogram and the PDF.

6. You are working on a project involving image processing, specifically analyzing the intensity distribution of grayscale images. You decide to create histograms for two different images, Image A and Image B, using different bin sizes.

   Image A:

   - The intensity values of the pixels in Image A range from 0 to 255.
   - You choose to create a histogram with **128 bins**.

- Calculate the width of each bin in the histogram for Image A.

Image B:

- The intensity values of the pixels in Image B also range from 0 to 255.
- This time, you choose to create a histogram with **16 bins**.
- Calculate the width of each bin in the histogram for Image B.
- If the histogram of Image A shows a peak at bin 64 and the histogram of Image B shows a peak at bin 4, explain what this might indicate about the pixel intensity distributions of the two images.
- Discuss how changing the number of bins affects the interpretation of the data represented by the histograms.
- If you were to visualize both histograms, how would you expect the shape of the histogram to differ between 128 bins and 16 bins? Provide a brief explanation of your reasoning.
- In a practical scenario, how might the choice of bin size impact further analysis or processing tasks, such as image enhancement or segmentation?

7. Consider two binary images:
   - **Image 1**: A black image with a small white dot in the center.
   - **Image 2**: A white image with a small black dot in the center.

i. Despite the distinct visual content of these two images, they might yield similar histograms due to the predominance of one color in each image and the small number of pixels of the opposite color.
ii. Analyze the histograms of both images and demonstrate how they can be similar despite the differences in their visual content. Discuss the implications of this observation in the context of image analysis.

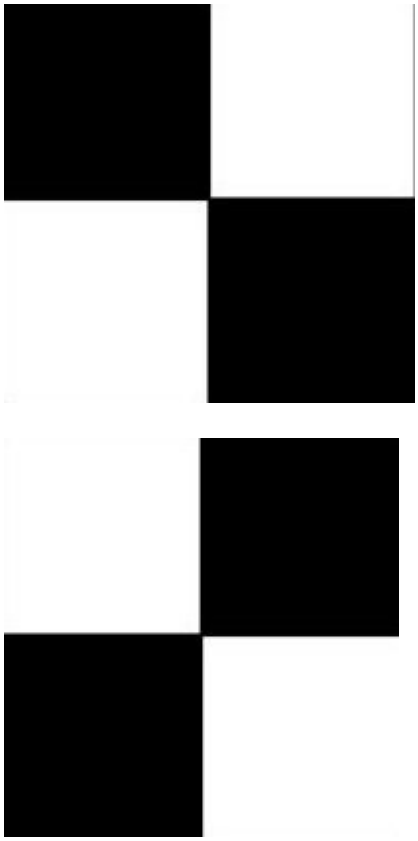
8. Consider an image matrix. A constant value is added to all the matrix entries. What is its impact on the image's histogram? Similarly, the matrix entries are multiplied by a constant. What is its impact on the image's histogram? Suggest the applications for both the operations.

9. Consider an image represented by the following matrix, where each entry corresponds to a pixel intensity in an 8-bit grayscale format:

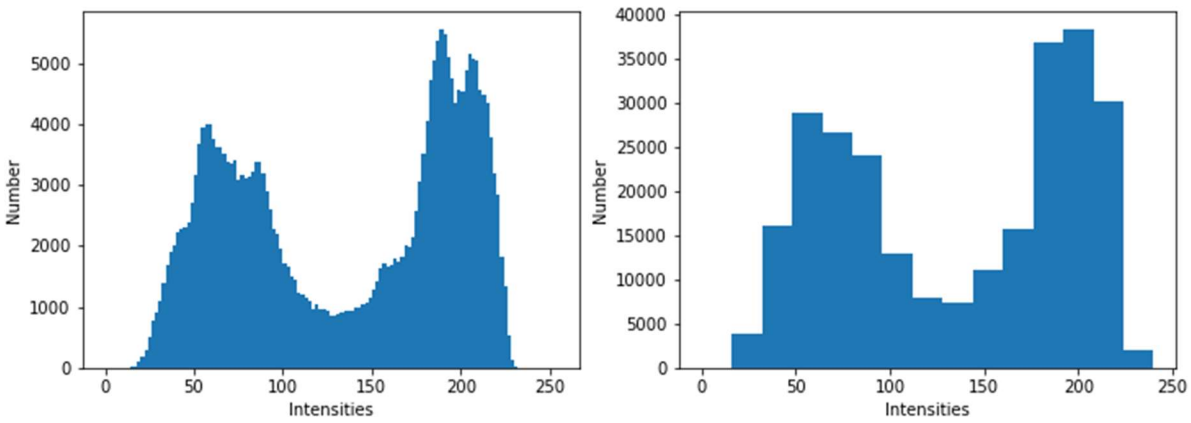
$$\text{Image Matrix} = \begin{bmatrix} 100 & 120 & 130 \\ 140 & 150 & 160 \\ 170 & 180 & 200 \end{bmatrix}$$

a. A constant value of C=30 is added to every entry in the image matrix. Calculate the new image matrix and describe the impact on the histogram. Specifically, explain how the histogram changes and what applications this operation could serve.

b. The image matrix entries are then multiplied by a constant factor of k=1.5. Calculate the new image matrix after multiplication and analyze the impact on the histogram. Discuss how the histogram changes and the potential applications of this operation in image processing.



An image and its two associated histograms are shown below. The histograms are displayed as a bar plot, constituted as a set of *bins*. The number (hence the width) of the bins are chosen by the user; in the example below, we choose 128 bins and 16 bins. Both histograms lie on [0,255] which are the intensity range of the image.



Distinguish two “modes” on the histogram. The one on the left (intensities around 75) corresponds to the dark tones in the image (mainly the background). The one on the right (intensities around 180) corresponds to the light tones (the petals and the center).

The following two images have the same histogram