# **Digital Image Processing** (EE60062)

Autumn 2015-16, Debdoot Sheet

Practice Problems

**Module: II**

1. You are provided with the following grayscale intensity image with pixel intensity represented in a 3-bit digital format.

$$\mathcal{I}_1 = \begin{bmatrix} 0 & 0 & 2 & 6 \\ 2 & 4 & 2 & 4 \\ 4 & 2 & 4 & 2 \end{bmatrix}$$

   Compute the histogram and pdf of $\mathcal{I}_1$?

2. Does the histogram of $\mathcal{I}_1$ have a sparse or a dense representation? Is it dense or sparse for its pdf?

3. Can you compute the dense representation of the histogram and pdf of $\mathcal{I}_1$ if you think that it has a sparse representation?

4. How many different methods can you employ to compute the dense representation of histogram and pdf of $\mathcal{I}_1$?

5. Can you estimate the mean squared error (MSE) between the pairs of different methods of estimating the dense pdf of $\mathcal{I}_1$?

6. You are provided with a RGB color image where each of its color planes are represented in a 3-bit digital format.

$$\mathcal{I}_2 = \begin{bmatrix} (4,4,4) & (4,4,4) & (0,0,0) & (6,6,6) \\ (2,2,2) & (2,2,2) & (2,2,2) & (0,0,0) \\ (2,2,2) & (4,4,4) & (4,4,4) & (2,2,2) \end{bmatrix}$$

   Compute the histogram and pdf of $\mathcal{I}_2$?

7. Compute the histogram and pdf of the intensity of $\mathcal{I}_2$?

8. Compare the histogram and pdf of $\mathcal{I}_1$ with the histogram and pdf of intensity of $\mathcal{I}_2$ and comment on their similarities and dissimilarities?

9. Compute the dense representation of the histogram and pdf of $\mathcal{I}_2$ and intensity of $\mathcal{I}_2$?

10. Describe an algorithm to find the local maxima and minima locations in a pdf of an image?

11. Use your above algorithm to find the maxima and minima locations in the actual pdf of $\mathcal{I}_1$ and in its different dense representation estimations?

12. Compute the integral of the actual histogram and pdf of $\mathcal{I}_1$ and its various dense representation estimations?

13. Compute the truncated 2D convolution and correlation of $\mathcal{I}_1$ and intensity of $\mathcal{I}_2$ with the following kernel

$$\mathbf{w} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

14. How many bits per pixel would you require to digitally store the result of the above 2D convolution and correlation?

15. Represent the equivalent spatial point operation when $\mathbf{w}$ is used for 2D convolution and correlation with a grayscale intensity image?

16. Compute the transformed intensity image $\mathcal{I}_3 = \{\log_2(i) \forall i \in \mathcal{I}_1\}$ using the direct algorithm and using look-up tables?

17. Compute the DFT of $\mathcal{I}_1$ and the intensity of $\mathcal{I}_2$?

18. Computationally relate the zero frequency component of the DFT of $\mathcal{I}_1$ and intensity of $\mathcal{I}_2$?

19. You are provided with the zero-frequency DFT of a grayscale intensity image and its mean image intensity. Can you find out the number of pixels in the grayscale intensity image?

20. Empirically verify the proof of the method proposed by you in the earlier question using $\mathcal{I}_1$?

21. You are provided with a grayscale intensity image of a circle with its center aligned to the center of the image represented in Cartesian coordinate space. Find its representation in the polar coordinate space?

22. Can you deduce a mathematical algorithm for polar to Cartesian coordinate space conversion using the bilinear interpolation rule?

# Module: III

1. You are provided with the following grayscale intensity image with pixel intensity represented in a 3-bit digital format.

$$\mathcal{I}_1 = \begin{bmatrix} 0 & 0 & 2 & 6 \\ 2 & 4 & 2 & 4 \\ 4 & 2 & 4 & 2 \end{bmatrix}$$

   Compute the negative image of $\mathcal{I}_1$?

2. If $\mathcal{I}_1$ is represented in a 8-bit digital format as $\mathcal{I}_2$, what would be the negative image of $\mathcal{I}_2$?

3. Compute the logarithmic transformed version of $\mathcal{I}_1$ using $g(\mathbf{x}) = \alpha + \beta \log_{10}(i(\mathbf{x}) + \gamma)$ with $\alpha = 1, \beta = 30, \gamma = 2$ to form the image $\mathcal{I}_3$?

4. How many bits would you require to store $\mathcal{I}_3$ using unsigned integers?

5. Compute the power law transformed version of $\mathcal{I}_1$ with $\alpha = 2, \beta = 1$?

6. Under what condition would a power law transform yield same result as a gamma transform?

7. Can you write the result of GHE of $\mathcal{I}_1$?

8. Can you write the result obtained by matching the histogram of $\mathcal{I}_1$ to the histogram of the following image?

$$\mathcal{I}_4 = \begin{bmatrix} 1 & 1 & 3 & 6 \\ 3 & 6 & 3 & 6 \\ 6 & 3 & 6 & 6 \end{bmatrix}$$

9. Compute the Weber, Michelson and RMS contrast of $\mathcal{I}_1$, the global histogram equalized version of $\mathcal{I}_1$ and $\mathcal{I}_4$? Comment on the effect of contrast enhancement on the images.

10. Perform CLAHE on $\mathcal{I}_1$ and $\mathcal{I}_4$, compute the contrast values and comment on contrast enhancement.

11. Perform BPDFHE on $\mathcal{I}_1$ and $\mathcal{I}_4$, compute the contrast values and comment on contrast enhancement.

12. White balance the following image using gray world approximation and white patch methods.

$$\mathcal{I}_5 = \begin{bmatrix} (4,4,4) & (4,4,4) & (0,0,0) & (6,6,6) \\ (2,2,2) & (2,1,2) & (2,1,2) & (0,0,0) \\ (2,2,2) & (4,3,4) & (4,4,4) & (2,2,2) \end{bmatrix}$$