AI3603: Computer Vision, Spring 2025

Indian Institute of Technology Hyderabad
Homework 4, Basic Image Processing
20 points. Assigned 16.04.2025, Due **11:59 pm on 20.04.2025**

Try not to become a man of success, but a man of value. – Albert Einstein

Instructions:

- It is **strongly recommended** that you work on your homework on an *individual* basis. If you have any questions or concerns, feel free to talk to the instructor or the TAs.
- For Q1, to better illustrate the effects of non-linear point operations (on gray scale images), use only copyright-free images from NASA's site: `http://apod.nasa.gov/apod/archivepix.html`. Convert color images to gray scale using any tool you like.
- For Q2, use the `Mandrill` image from the University of Southern California's image database at `https://sipi.usc.edu/database/download.php?vol=misc&img=4.2.03`.
- You are free to use Copilot. Please turn in your prompts.
- Please turn in Python Notebooks with the following notation for the file name: `your-roll-number-hw4.ipynb`.

1 Gray Scale Point Operations (5)

Write a program/function to do the following:

1. Perform simple linear point operations for the following cases:
   (a) **J = P.I**. (1)
   (b) **J = P.I + L**. (1)

   In each case, verify that the histogram of **J** is related to the histogram of **I** according to the relation discussed in class. You can use any standard library for histogram computation and plotting.
2. Full scale contrast stretch (FSCS). Verify your result by printing the min and max pixel values before and after applying FSCS. Also, plot the histogram of the image before and after applying FSCS. (1)
3. Log magnitude compression (always followed by FSCS). Plot the histogram of the image before and after applying log magnitude compression. (1)
4. Gamma correction: $\mathbf{J} = \mathbf{I}^{\gamma}$ with $\gamma = 1.4$. Clip pixel values greater than 255 to 255. Plot the histogram of the image before and after applying gamma correction. (1)

Now test your implementation using copyright-free images from NASA's site. Compare the original image with the output of each of the three operations above. Comment on the quality of the original images based on the output of these operations. Make sure your image display function doesn't do any further contrast stretching.

2 Edge Detection

In this problem, you will write a program to compute the edge map of an image. See instructions for image.

2.1 Gradient Edge Detectors (10)

1. Use the following gradient operators:
   (a) Centered 2-D differencing.
   (b) Roberts operator.
   (c) Prewitt operator.
   (d) Sobel operator.
2. Estimate gradient magnitude using the following definitions:
   (a) $M(i,j) = \sqrt{\Delta_x^2(i,j) + \Delta_y^2(i,j)}$
   (b) $M(i,j) = |\Delta_x(i,j)| + |\Delta_y(i,j)|$
   (c) $M(i,j) = \max\{|\Delta_x(i,j)|, |\Delta_y(i,j)|\}$
3. Threshold the magnitude map using an empirical threshold τ to find the edge map E.

2.2 Laplacian Edge Detectors (5)

1. Compute the Laplacian using the convolution template

$$\begin{bmatrix} 0 & +1 & 0 \\ +1 & -4 & +1 \\ 0 & +1 & 0 \end{bmatrix}$$

2. Compute the edge map E as the output of a zero crossing detector.