Assignment-1
Digital Image Processing

1. Follow the specified repository structure.
2. Make sure you run your Jupyter notebook before submitting to save all outputs.
3. Make sure to mention your name and Roll Number in the submitted **.ipynb** file.
4. Appropriately label every figure and subplot. Make sure to follow the output format (if given) as it carries marks.
5. Allowed libraries: numpy, matplotlib, opencv (only basic functions like imread, imshow, cvtColor).
6. Make an effort to vectorise your code as it carries 20% weight.

1 Lenna's Plight [10]

Lenna has had a really beautiful image taken of herself and she wishes to send it to a modeling agency. The problem, however, is that Lenna's images are really detailed and hence too large to send. Lenna doesn't have access to the internet (to use online reduction tools) and she only ever went to art school (so she can't do it herself). Help Lenna by reducing the size of her image by quantizing it in **n** (1-8) number of bits and discussing the effects of this quantization by plotting the new images. Her original image is in the attached **src_img** folder.

Fig- 1 Lenna's Photoshoot

Output Format- A 2x4 (or 4x2) grid containing the quantized images and a short explanation of the effect.

2 Sorry, this is a long one [70]

You are required to complete the individual subtasks given within this question. All the subtasks have to be performed using two images- any one color image of your choice and **image.jpeg** which just so happens to be one of the several masterpieces clicked by the world-famous photographer Roon. (Make sure to label every subplot with an appropriate title. **A** is the image of your choice and **B** is **image.jpeg**). The subtasks are as follows-

1. **Write a *histequalize()* function that can be used to equalize the histogram of an image that is passed to it [5]**

2. **In a single figure (3x2), plot A and B, their respective histograms, and their respective equalized histograms using the *histequalize()* function you have written. Comment on whether this is good representation for a colored image's histogram [10]**

3. **In a single figure (3x3) plot the separate RGB channels of A, the histograms of these respective channels, and the equalized histograms of these respective channels. Do the same for B (in a separate figure) [15]**

4. **In a single figure (1x3) plot the separate RGB channels of A, after histogram equalization is performed. Do the same for B (in a separate figure) [5]**

5. **In a single figure (2x2) plot A and B (after merging the equalized channels) and plot their respective histograms. [10]**

6. **Concatenate the equalized respective RGB histograms for A and B that you had in subtask-3. Plot these in a single figure (2x2) along with a graph (for A and B both) that demonstrates the difference between the equalized histogram you had in subtask-5 and the concatenated histogram. [20].**

7. **Lastly, comment on your work and what you may have learnt from these subtasks as a whole, in not more than 50 words (strict). [5]**

Fig- 2 image.jpg

3 Who's the Best? [20]

You are a private investigator hired by IIIT-Hyderabad to help them decode cryptic images they are receiving in the mail. Apparently, decrypting these images will result in this year's Felicity coordinators actually doing a good job (don't ask how). The message has, apparently, been cryptically stored in the LSB plane. Complete the following subtasks to save Felicity-

1. **Pick up the cryptic photo titled as 'X_mod.png' where X is the last digit of your Roll Number and extract the cryptic image from it. Plot this cryptic image. [10]**

2. **Who is the best? Especially whom? [1]**

3. **Can you explain why the cryptic image was weirdly proportioned? (Hint: Look at the dimensions of the decrypted message) [1]**

4. **Using your past experience with helping Lenna (in Question-1) can you explain how the cryptic image was created? [3]**

5. **Write your own *crypt()* function that takes two color images, a message image and a base image, and embeds the message image in the base image (as done for cryptic images above). Plot the base image and the encrypted image side-by-side. [2.5]**

6. **Lastly, write your own *decrypt()* function that can extract a visual message from the kind of encrypted images that your *crypt()* function generates. [2.5]**

4 It just doesn't end, does it [45]

Your work on image processing is a world-wide hit, especially what you did in Question-2. Impressed by the work you did, the world's current best image processer, Sumain., hires you to work under her. Given your experience, Sumain. asks you to take the same images, **A** and **B**, and complete the subtasks-

1. **Since you have been able to extract the individual color channels from both A and B, considering that 'a' is the last digit of your Roll Number, apply the following Linear Piece-wise transformations and in a single figure (2x2) plot the original images as well as the transformed images- [10]**

Red Channel Transformation

$$transformed(x) = \begin{cases} x + a & \text{if } 0 \leq x \leq 100 \\ \frac{x}{a} + 2a & \text{if } 100 < x \leq 200 \\ 255 & \text{if } 200 < x \leq 255 \end{cases}$$

Green Channel Transformation

$$transformed(x) = \begin{cases} 5x + 1 & \text{if } 0 \leq x \leq 128 \\ \frac{a}{x} + 8 & \text{if } 128 < x \leq 255 \end{cases}$$

Blue Channel Transformation

$$transformed(x) = \begin{cases} 255 & \text{if } 0 \leq x \leq 75 \\ x & \text{if } 75 < x \leq 200 \\ 0 & \text{if } 200 < x \leq 255 \end{cases}$$

2. **Plot the transformations for the three separate channels of A and their line of best fit in a figure (3x1). Do the same for B (in a separate figure). [5]**

3. **Read both A and transformed(A) and plot the input vs. output pixel intensities for the three separate channels along with a line of best fit in single figure (3x1). Do the same for B (in a separate figure). Also print the equation of the line of best fit for each channel. Explain what you see and why? [7]**

4. **Now, plot all these aspects of the separate RGB channels in a single plot (1+1+1+1+1+1 for three separate channel for 2 images) (the input vs. output pixel intensities for A and transformed(A); its line of best fit; the line of best fit of the transformation equations themselves). [3]**

5. **Taking the equations of the line of best fit that you have received in subtask-3 for each channel, apply it as a linear transformation for the respective channels to the original images, A and B. Call these *mod_trans(A)* and *mod_trans(B)* Plot the transformed images in a single figure (1x2). [8]**

6. **Read *transformed(A)* and *transformed(B)* (you got them in subtask-1) and *mod_trans(A)* and *mod_trans(B)* (you got them in subtask-5) and repeat subtask-3 (considering *transformed(x)* as input and *mod_trans(x)* as output. [7]**

7. **Lastly, look at *transformed(x)* and *mod_trans(x)* and comment what you think is the difference. Can this transformation be called a filter? [5]**