Introduction

1. Follow the specified repository structure.

2. `src` will contain the Jupyter notebooks used for the assignment.

3. `images` will contain images used for the questions.

4. Follow this directory structure for all assignments in this course.

5. Make sure you run your Jupyter notebook before committing, to save all outputs.

6. Make sure you commit and push your work regularly.

7. Allowed libraries: numpy, matplotlib, opencv (only basic functions like imread, imshow, cvtColor).

Questions

1. (30 points) **Harry's Escape**

   The Harry Potter series are a widely acclaimed global phenomenon now. In the concluding book, Harry Potter and the Deathly Hallows, Voldemort has his evil forces in place to capture Harry while he tries to safely reach The Burrow. In order to escape successfully without being traced by his nemesis, all 6 of Harry's associates use the Polyjuice potion to disguise themselves as his alter egos so that his enemy is left baffled and can't determine who the real Harry Potter is.

   The smartest auror in the team and your most experienced associate, Mad Eye Moody further advises you to make the plan foolproof by covering your tracks through the generation of fake images. To teach you, Harry, Moody has shown an example of image matting where you will take an image of yourself on a green screen and add a fake background to it.
   How does the green screen help in this task?

   (a) Foreground Image　　　(b) Background Image　　　(c) Result

1. Generate images for your fake trail to leave for Voldemort and the death eaters using this method.

   (a) Test your implementation using the provided foreground(`fg.jpg`) and background(`bg.jpg`).

   (b) Graft *Harry Potter* onto *Hogwarts*. Find this magic school's image from the internet.

   (c) Be creative and try out with different foreground and background images of your choice and show the results.

2. Moody also wants to know how many images of size `720 x 576` can be stored if cloud of size 2 GB is available. Assuming images are stored for displaying on standard displays, calculate the number of images you can store in the cloud.

Use markdown in jupyter notebook to explain your solution.

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2. (10 points) **Colin's Storage Issues**

Colin has just joined *hogwarts* and brought a *muggle* camera with him, He is very excited about all the magical things around him and wants to take many photos. But the problem, it has limited storage of 500 MB. You, as his friend, have to help him by doing the following task. Calculate the maximum dimensions of one image if colin wants to take 200 images back with him when he goes home for summer vacation. Assume all image shapes to be squares.

Colin is very curious and expects explanations for all the steps you take for the above task, so explain each step with theoretical details.

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3. (15 points) **Identifying the Basilisk**

In the third installment of the Harry Potter franchise, there's an obnoxious and destructive creature, the basilisk, on the loose. Whoever sees it directly with their naked eyes shall immediately succumb to death. Colin Creevey, a student at Hogwarts, used his camera to take a picture and the basilisk was inadvertently caught in the frame. He didn't die as he looked at the evil entity indirectly, through his camera lens but was stunned into petrification and his camera film was burned to a crisp as a result of the close impact.

You have been assigned the dangerous task of taking a photo of the basilisk so that it can be identified and eventually slain. The creature has extremely quick defences and

you must take the picture from as far away as possible to avoid a lethal attack while also ensuring that the film is preserved and the photo isn't rendered useless.
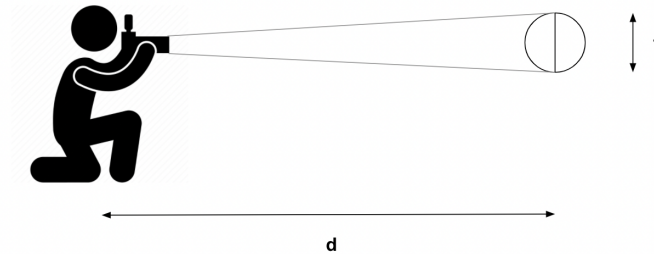

Figure 2: You taking a photo of the target

Your camera has a square CCD sensor of dimensions `10 x 10 mm` with `1024 x 1024 pixels`. Focal length of camera lens is equal to `43.5 cm`. You need to ensure that the target covers atleast `390 pixels` in height in the captured image. As long as you are at a distance of `240m`, you are safe from the basilisk. Calculate the height of the creature. Use markdown to show all the steps and give explanation for each step.

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4. (30 points) **Draco Strikes Again!**
Draco abhors all *muggle* objects and naturally hates Colin's camera. He took all the images and corrupted them so Colin's memories are ruined. Colin is devastated and doesn't trust anyone. You have to prove your skills to Colin and then help retrieve his corrupted images.

   1. Write a function `bitQuantizeImage` which takes an 8-bit image `im` and `k`, the number of bits to which the image needs to be quantized to and returns the k-bit quantized image. (10 points)

   2. Colin wants see how good you are, so prove yourself by running the above function on `filch.jpg` and find all 8-bits quantization results.

   3. Furthermore he wants you to show all the bit planes of `hermoine.jpg`.

(a) filch.jpg
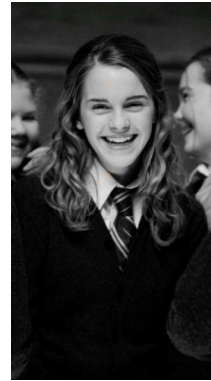
(b) hermoine.jpg

4. Now that you have gained the trust of Colin Help him guess the corruption procedure for a target *person*'s image, ***person*_corrupt.jpg** The correct images that you know for that corresponding *person* from Colin's memory represented by ***person*.jpg**

You will be selecting the target person for whom you will be guessing the corruption procedure using the following method out of the following names {`harry, ron, dobby, luna, ginny`}.

Calculate the `modulus` of your roll number against 5. Say it is `k`.

- For k = 0 select harry (corresponding files are `harry.jpg` and `harry_corrupt.jpg`)
- For k = 1 select ron (corresponding files are `ron.jpg` and `ron_corrupt.jpg`)
- For k = 2 select dobby (corresponding files are `dobby.jpg` and `dobby_corrupt.jpg`)
- For k = 3 select luna (corresponding files are `luna.jpg` and `luna_corrupt.jpg`)
- For k = 4 select ginny (corresponding files are `ginny.jpg` and `ginny_corrupt.jpg`)
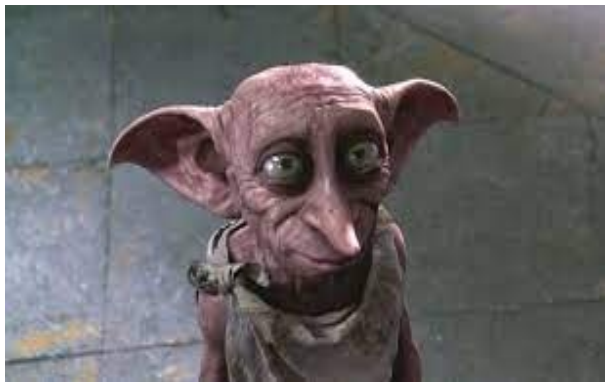

(a) harry.jpg

(b) harry_corrupt.jpg

(a) ron.jpg

(b) ron_corrupt.png

(a) dobby.jpg

(b) dobby_corrupt.jpg

(a) luna.jpg

(b) luna_corrupt.jpg

5. (15 points) **Snape and The Order of The Phoenix**
   In the Harry Potter Saga, Snape is basically a double agent who appears to report to Voldemort initially. Severus Snape attends the highly confidential meetings of the *Order of the Phoenix* at Number 12, Grimmauld Place. He infiltrates the group and sees all the members of the Order. However the picture he has as proof is taken in very low light

and saved as `phoenix-bad.jpg`.

Figure 8: Low light proof

As Snape you have the following tasks to convince the death eaters of your loyalty towards them,

1. Write a function `linContrastStretching` which takes any image `im`, integers `a` and `b` that enhance the contrast such that the resulting intensity range is $[a, b]$.

2. Use the function to improve the intensity of `phoenix-bad.jpg` and supposedly assist Voldemort.

3. Show the input image and the resultant image along with their `colorbars` (a strip containing `k` most frequently occurring colors). Give suitable explanation for the resulting colorbars.

Bellatrix wants you to be debriefed first just after your return. She has your wand and all high-level clearance passes on hold till then. Explain the improvement in the contrast theoretically, so that she releases your documents and you can carry on with your spying assignment.

6. (30 points) **Hermoine and linear transforms**
   Hermoine came across a new spell in her potions class that is used to transform the gray level of the image. She *for the first time* is not able to understand the topic! and she has an assignment due today.
   you have to help her in her assignment-

   1. Write a function `piecewiseLinTransform` to implement a piecewise linear transform

   $$g(z) = K_1^i \cdot z + K_2^i \; ; \quad a^i \leq z \leq b^i \tag{1}$$

   The function takes an input grayscale image, coefficients K_1, K_2 and intervals $[a, b]$ for each linear segment and produces the transformed output image.

2. Run the images through `piecewiseLinTransform` on `snape1.jpg` and `hagrid.jpg`. The piecewise linear functions to be used are given for each image.
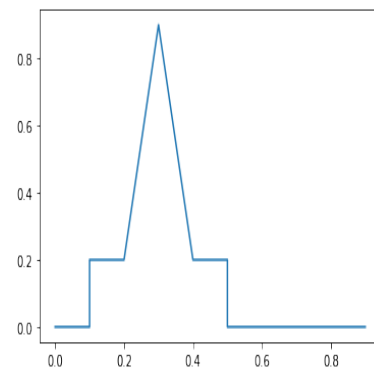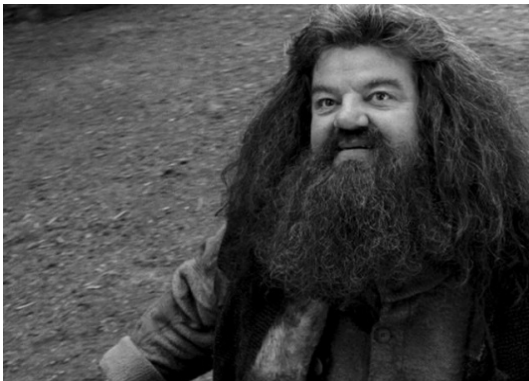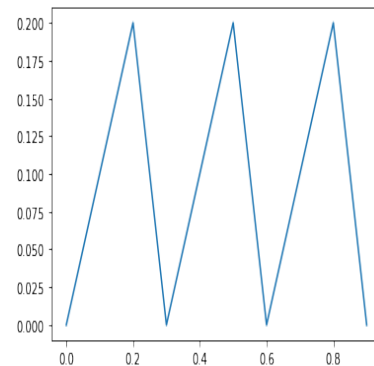
3. Take your photo, convert to grayscale, and run `piecewiseLinTransform` using any custom piecewise linear function that you like. Plot the function used.

Even after your demonstration *Hermoine* didn't understand. So, explain all the steps that you performed in detail.

7. (30 points) **The Marauder's Map**
In the series, Harry has been given the Marauder's Map by Fred and George Weasley. He happens to spot some fishy symbols on the map when Lupin suddenly confiscates it from him. He is only left with an image file named `map.jpeg`. To explain the bizarre turn of events to Lupin, Harry needs to act fast and try to decipher the images he saw quickly.
He needs to put his Digital Image Processing skills to use for retrieving this information. Since this is a covert operation, you will **NOT** be using any inbuilt functions for implementing the histogram processing operations.

- Write a function `histEqualization` which takes a grayscale image `img`, and applies histogram equalization on the entire image.

- Apply the function on `fred.jpeg` and display the input image and the resultant image. Plot the histograms for input and resultant image and explain the changes you observe for each image.

- Write a function `histMatching` which takes an input image and a reference image and applies histogram matching on the input image by matching the histogram with that of the reference image.

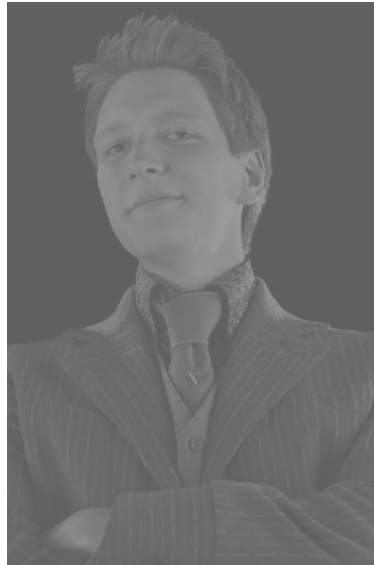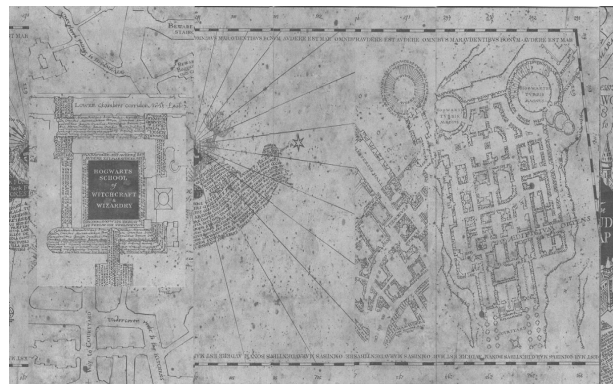- Try histogram matching on `map.jpeg` and `map-reference.jpeg`.

Figure 11: Fred

(a) map.jpeg

(b) map-reference.jpeg

8. (30 points) **The Seven Horcruxes**
   In Harry Potter and Half Blood Prince, Dumbledore and Harry set off to destroy one

of Voldemort's seven horcruxes. However it lies on a strip of land, in the middle of a dark cave, surrounded by water on all sides. The dark and treacherous waters need to be navigated with caution as they are home to the monstrous creatures, the inferi. Step up into the role of Dumbledore and use gamma transform to safely reach the isle and carry out the important task.

- Write a function `gammaTransform` that implements $s = r^\gamma$ on a grayscale image and vary γ. Report your observations when γ is less than 1 and when γ is greater than 1.

- Apply gamma transformation on `locket.jpeg` to increase the brightness in the image. Report your observations.

- Apply gamma transformation on `voldemort.jpeg` to decrease the brightness in the image. Report your observations.
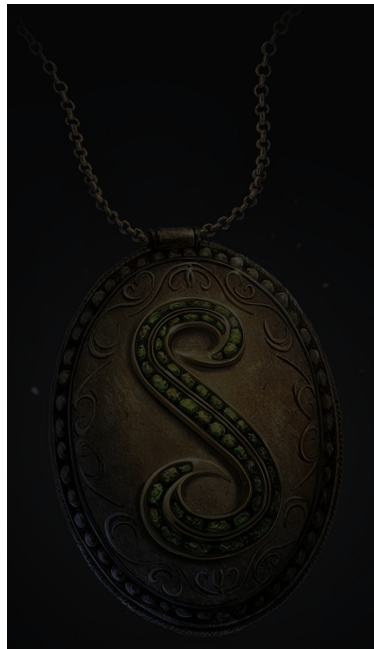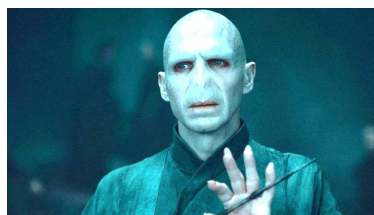

Figure 13: Salazar Slytherin's Locket

Figure 14: Lord Voldemort

9. (40 points) **Is that the best you got**?

    1. You are provided with 4 grayscale images (`neville1.jpg`, `neville2.jpg`, `neville3.jpg`, `neville4.jpg`) with different contrast levels, which correspond to parts of the same image.

    2. Retrieve the original image using these four images as best you can. You can use a combinations of techniques used in this assignment.

    3. You will be evaluated on how uniform your final output looks. Clarity is not important as details are not present in the images. Use any of the above methods to achieve a common gray level as best you can.

Figure 15: Neville and Voldemort