E9 241 Digital Image Processing

Assignment 01

Due Date: September 2, 2022 - 11:59 pm **Total Marks:** 75 + 15

Instructions:

For all the questions, write your own functions. Use library functions for comparison only.

- Your function should take the specified parameters as inputs and output the specified results.
- Also provide the wrapper/demo code to run your functions. Your code should be self contained i.e. one should be able to run your code as is without any modifications.
- For python, if you use any libraries other than numpy, scipy, scikit-image, opencv, pillow, matplotlib, pandas and default modules, please specify the library that needs to be installed to run your code.
- Along with your code, also submit a PDF with all the results and inferences. Include answers to subjective questions, if any.
- Put all your files into a single zip file and submit the zip file. Name the zip file with your name.

---

1. **Histogram Computation:** Compute the histogram of the following images `GulmoharMarg.png`, `GulmoharMargDark.png`, and `GulmoharMargBright.png`, by finding the frequency of pixels for each intensity level $\{0, 1, \ldots, 255\}$. For each image, show the histogram by plotting frequencies w.r.t. intensity levels. Comment on what you observe. Also verify one of the plots with MATLAB / Python in-built functions for computing histogram.

   Histogram function:
   Input: Grayscale image
   Output: Frequencies of each intensity level (a list/vector of size 256)

   (10 Marks)

2. **Otsu's Binarization:** In the class, we showed that $\sigma_w^2(t) + \sigma_b^2(t) = \sigma_T^2(t)$, where t is the threshold for binarization. Binarize the image `coins.png` by sweeping over all integer values of t and plot $\sigma_w^2(t)$, $\sigma_b^2(t)$ and $\sigma_T^2(t)$ w.r.t. t. Verify that the minimum of $\sigma_w^2(t)$ and maximum of $\sigma_b^2(t)$ is located at the same threshold.

   Within class variance function:
   Input: Grayscale image, threshold
   Output: Within class variance

   Between class variance function:
   Input: Grayscale image, threshold
   Output: Between class variance

   (20 Marks)

3. **Foreground Extraction:** For the image `IIScText.png`, separate the foreground text from the background using otsu binarization. Display the text in `IIScText.png` on the background image `IIScMainBuilding.png`.

   Image superimpose function:
   Input: Text image, background image
   Output: An image with the text superimposed on the background image

   (15 Marks)

4. **Connected Components:** Binarize the image `Shapes.png` and count the total number of shapes using connected component analysis. Also compute the number of occurrences of the circles.

Shape count function: Input: Image Output: Number of shapes, number of circles

(30 Marks)

5. **Optional Bonus Question - MSER:** Maximally Stable Extremal Regions (MSER) correspond to regions of connected components which when thresholded around a certain threshold are stable in terms of the size of the component. This allows an adaptive thresholding method where different regions can be thresholded using different thresholds automatically. Determine the binarized image for `DoubleColorShapes.png` based on MSER using the following steps:

   (a) Sweep over all thresholds.

   (b) For each threshold, determine connected components in the image.

   (c) A connected component is termed an MSER if the size of the component does not change much (within δ) for a small perturbation ϵ in the choice of the threshold. Note that both δ and ϵ are parameters that need to be chosen. Determine the stable threshold for each connected component.

   (d) Ignore extremely large or extremely small connected components in the above analysis.

   Compare the performance of Otsu's binarization with the above method on `DoubleColorShapes.png`. Think about why Otsu will not be able to extract both the words in this case.

MSER function: Input: Image Output: MSER binary image, Otsu binary image, number of connected components detected by MSER, number of connected components when applied on Otsu binarized image.

(15 Marks)