CS 111 Programing Assignment 4: Histogram Processing

Submission instructions:

Please **submit your code, output images and a PDF file (containing the output images) in a single zip file** to Canvas. You must also **submit the same PDF file** to Gradescope.

BOTH submissions are required for full points.
Your work is due by **11:59 p.m. on Wednesday, the 15th of May**.

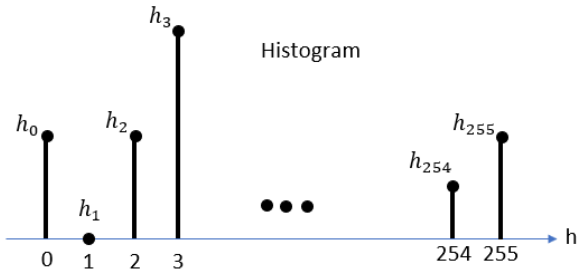
Introduction:

This programming assignment is focused on histogram processing.

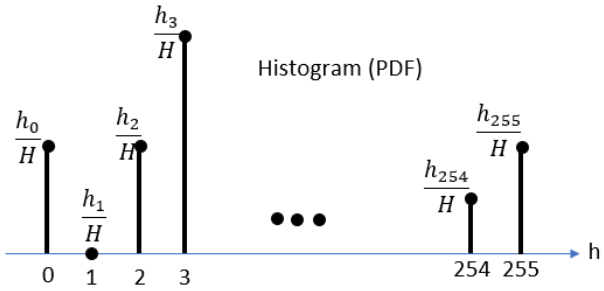
You will **NOT** be allowed to use any OpenCV functions unless told otherwise. In this assignment, you will work with gray images only. So, use CV_LOAD_IMAGE_GRAYSCALE when reading your images.

I. Histogram Matching:

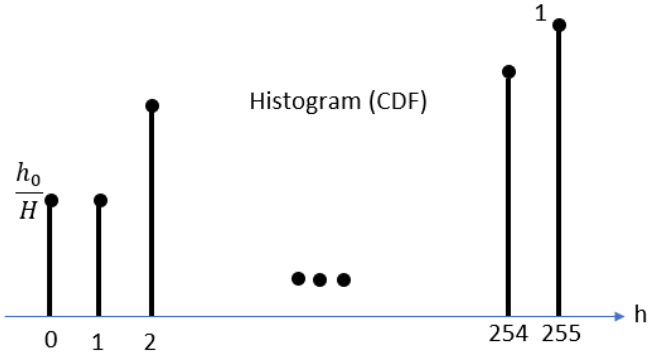
a. Histogram equalization is a special case of histogram matching. In histogram matching, we have a current histogram (the histogram of our image) and a target histogram. The goal is to change the pixel values of the current image such that the current histogram becomes similar to the target histogram.
b. To perform histogram matching, we first calculate the *Cumulative Distribution Function (CDF)* of both current and target histograms. If we divide the histogram of an image by the number of pixels in that image, we get a *Probability Density Function (PDF)*. The sum of all the values of a PDF 1. If an image has H pixels and the histogram is:



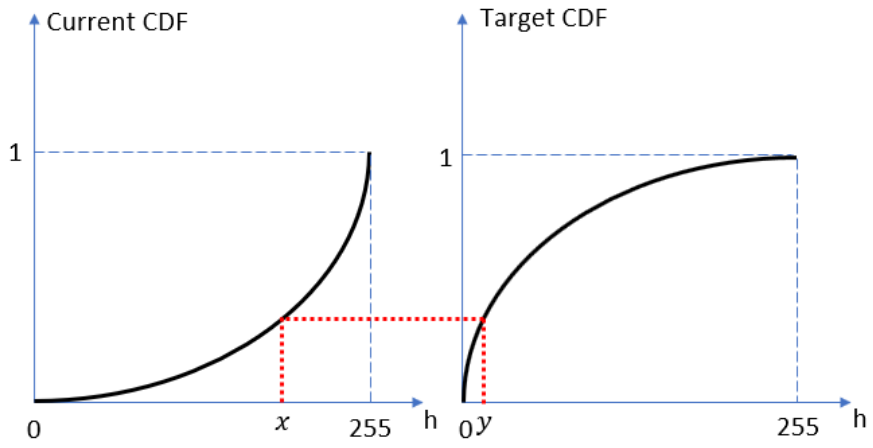
Then by dividing each bin by the number of pixels, you will get the PDF as:



The CDF, calculated as $CDF(h) = \sum_0^h \quad PDF(i)$, looks like this:

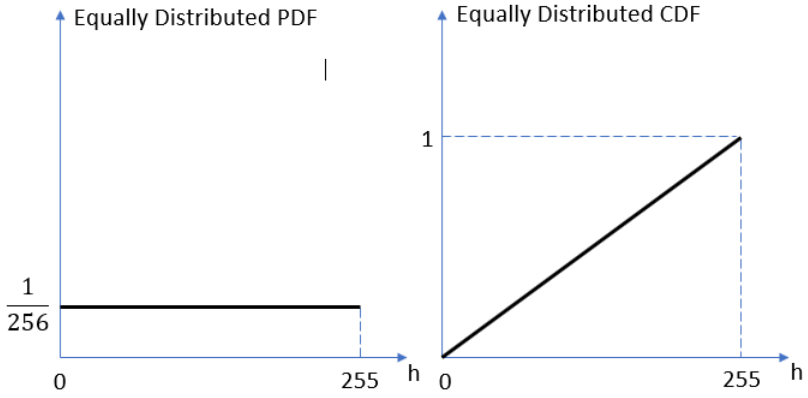


c. Once we have the CDF of the current and target histograms, we can find the mapping to perform the histogram matching. For each gray level in the current image, you should find its CDF value, and then find the gray level which has the same target CDF value. For example, in the image below a gray level x is chosen. It's value in the current CDF is equal to the target CDF value of gray level y. Therefore, x should be mapped to y. Assume the current CDF is denoted by the function F and the target CDF is denoted by the function G. Then, the relation between x and y is $y = G^{-1}(F(x))$.



II. Histogram Equalization:

a. It is desirable that the probability distribution of gray levels be equally distributed. If so, the image utilizes the dynamic range of possible values (e.g. 0-255) and will have optimal contrast. The equally distributed histogram PDF and CDF are as follows:



b. Here, when you are working with discrete values, the PDF and CDF will be discrete functions (bar histogram in earlier images) and when you want to find the equal CDF value between the current and target CDF they may not match. In this assignment, you should search for the closest CDF value. You may implement any search algorithm for searching the closest CDF value.

c. You should write the function *Mat HistogramEqualization(Mat I)* that takes an image as input and returns the histogram equalized output image. This function is composed of multiple functions that you should complete for this section:

i. ***FindPDF:*** Input: gray image; Output: the histogram (in the format of PDF).
ii. ***FindCDF:*** Input: PDF; Output: CDF.
iii. ***FindEqualMapping:*** Input: CDF; Output: mapping for equalization.
iv. ***ApplyEqualization:*** Input: image, mapping; Output: equalized image.

```
Mat FindPDF(Mat I);
Mat FindCDF(Mat pdf);
Mat FindEqualMapping(Mat cdf);
Mat ApplyEqualization(Mat I, Mat mapping)

Mat HistogramEqualization(Mat I) {
  Mat currPDF = FindPDF(I);
  Mat currCDF = FindCDF(currPDF);
  Mat eqMap = FindEqualMapping(currCDF);
  Mat output = ApplyEqualization(I, eqMap);
  return output;
}
```

Complete all four functions that compose the "*HistogramEqualization*" function in "pa4.cpp", and apply it on the input image "aerial.png". You should submit the output image "aerial_eq.png" along with the code in "pa4.cpp" in your zip file.