Assignment #2 Image Enhancer

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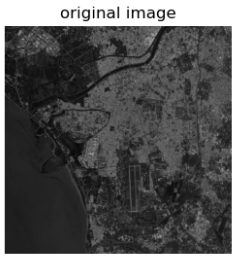
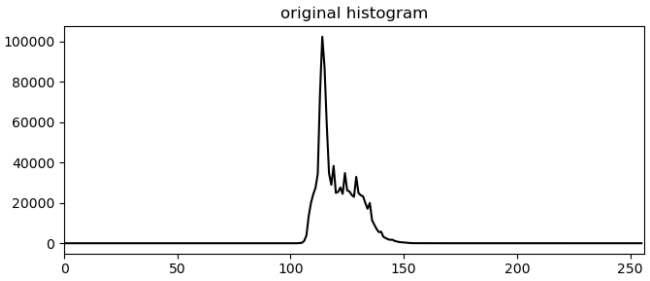
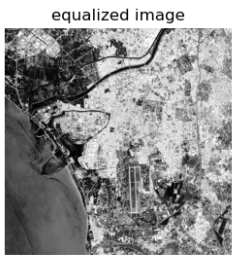
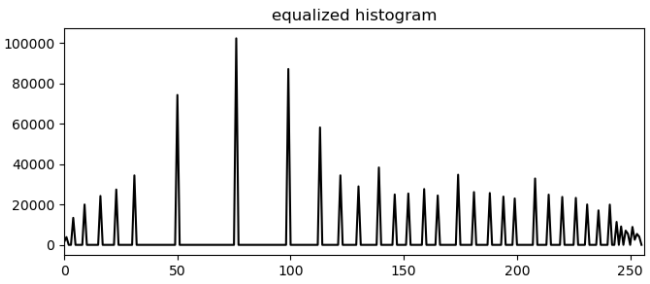
1. **Implement the histogram equalization algorithm and apply it to the test images show below. Show the histogram before and after the histogram equalization.**

Tainan

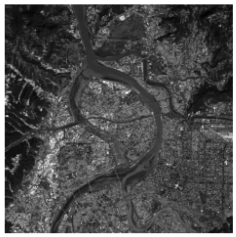


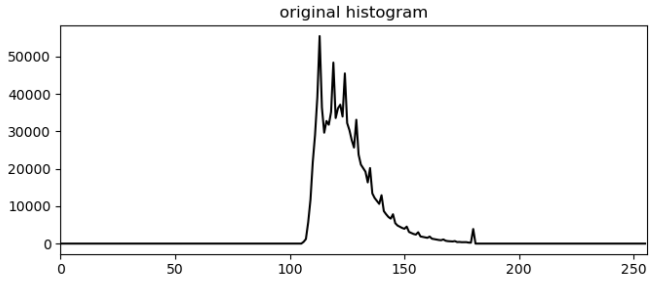


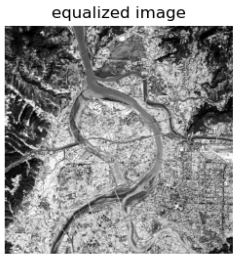


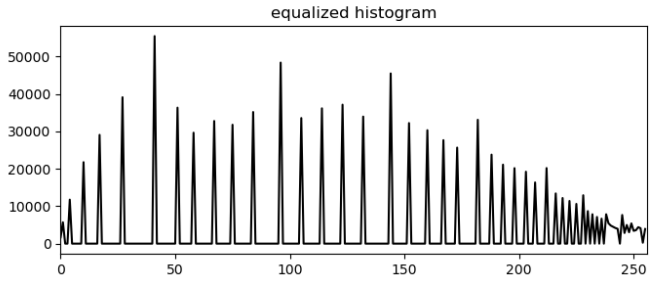


Taipei









2. **Explain why the discrete histogram equalization does not yield a flat histogram.**

Histogram equalization is a technique used to enhance image contrast by redistributing pixel intensities. While it is often discussed in the continuous domain in textbooks, where values are assumed to be infinite within any interval, real-world digital images operate in the discrete domain. This difference between theory and practical implementation explains why the process does not result in a perfectly flat histogram.

In the continuous domain, the concept is that pixel intensities are

redistributed smoothly across the entire range of values. However, in the discrete domain, which is used for digital images, there are a fixed number of possible intensity values (typically 256 levels for an 8-bit image). The histogram is composed of these discrete intensity levels, and when histogram equalization is applied, the process simply remaps one intensity value to another, rather than redistributing all values across the range.

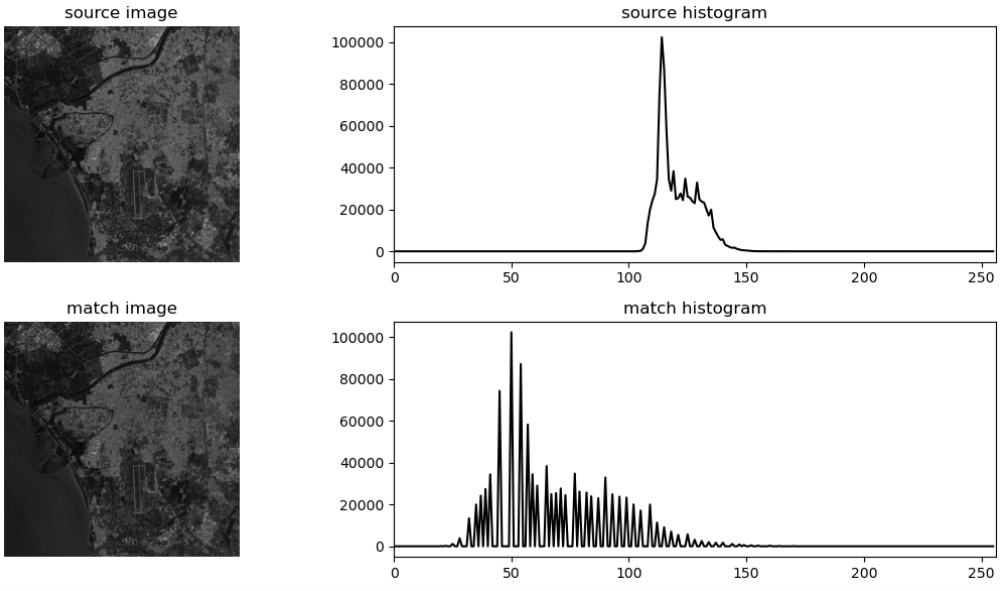
This remapping maintains the original relationship between pixels of the same intensity. In other words, if multiple pixels have the same intensity before equalization, they will still share the same intensity afterward, even though the overall distribution of intensity values may have changed. The discrete equalization process stretches or compresses the histogram but does not fundamentally alter the fact that there is a fixed number of intensity levels.

Moreover, during histogram equalization, a discrete sum is used to approximate the continuous integral of the cumulative probability distribution function (CDF) of the pixel intensities. Since pixel values are discrete integers and the total number of pixels is also an integer, this approximation introduces inherent limitations. The rounding and quantization involved in this process prevent a perfectly uniform or flat histogram from being achieved.

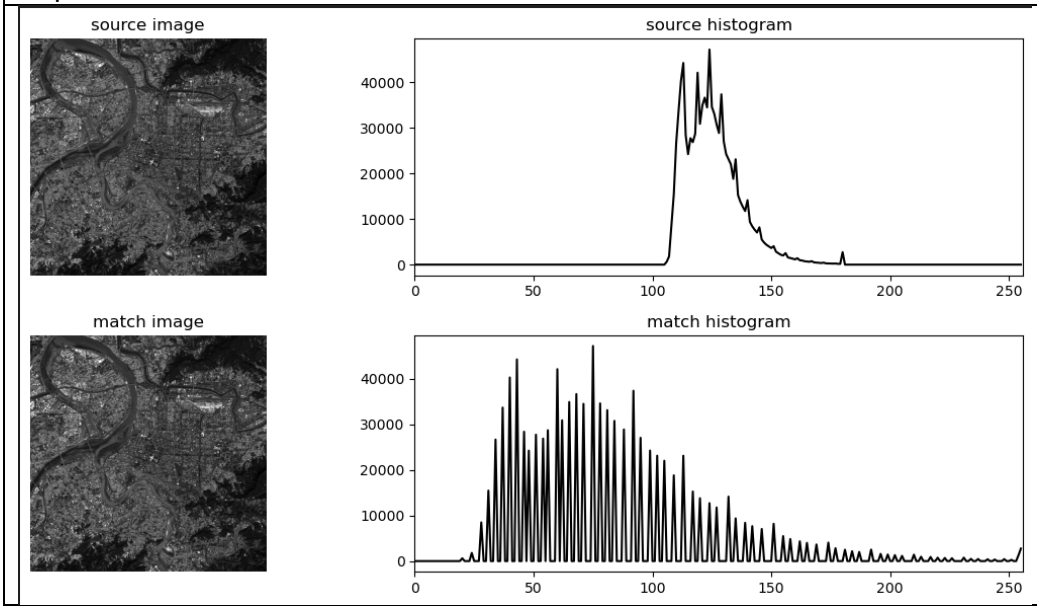
In summary, while histogram equalization improves image contrast, the discrete nature of digital images and the approximation involved in calculating the CDF mean that the result is not a perfectly flat histogram. Instead, pixels are remapped in a way that enhances contrast but maintains the original structure of intensity values in a discrete form.

3. **Implement the histogram matching algorithm and use this algorithm to balancing the colors of the tested images.**

Tainan



Taipei



In the first image (Tainan), the source image's histogram shows a sharp intensity peak around 110, indicating most pixels are concentrated in a narrow range, resulting in low contrast. After histogram matching, the pixel intensities are redistributed more evenly across the range, improving the contrast. The new histogram is more spread out, reflecting better alignment with the target histogram and improved visual quality.

In the second image (Taipei), the source image's histogram shows a dominant peak between 100 and 150, suggesting low contrast and limited intensity variation. After applying histogram matching, the intensities become more evenly distributed, resulting in a more balanced image with enhanced contrast. The matched histogram displays a wider spread of intensities, improving the visual balance.

In both cases, the histogram matching algorithm effectively redistributes pixel values, aligning the source images more closely with the target histograms. While the histograms are not perfectly smooth, indicating that quantization effects and the discrete nature of digital images may cause uneven intensity distribution, the overall contrast and quality of the images are enhanced. The sharp peaks in the matched histograms suggest that specific intensity values were successfully aligned, contributing to the improved visual quality of the images. This process effectively transforms low-contrast images into more balanced, visually appealing ones.